MESOSCALE METEOROLOGY OF THE NORTON SOUND REGION

by

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ABSTRACT

An analysis of the 1964-1968 surface winds, pressures and temperatures at weather stations surrounding Norton Sound was performed. The stations chosen for their network geometry were Northeast Cape (St. Lawrence Island), Nome, and Unalakleet. Surface pressure data from this network were used to calculate geostrophic wind velocities for the Sound center which are "immune" from orographic or thermally generated effects seen to exist only in a 20 km zone seaward of the coast. The stations were particularly suited for the mesoscale part of this study because Nome's coastline is perpendicular to Unalakleet's and each has small mountain ranges inland. Northeast Cape was outside the Sound on the tip of a small peninsula. This allowed for simultaneous comparison of sea breeze effects (summer) and orographic effects (mainly winter) on surface wind velocities at the three sites. The most important parts of this study are broken down into general characteristics, orographic effects, thermal effects and combined thermal and orographic effects.

The surface winds at the three coastal sites showed a higher steadiness when the sea in their vicinity was ice covered. The February average temperatures reached -19°C for all three stations and the July average temperature at Unalakleet reached 12°C (other two stations slightly lower). The Northeast Cape temperatures were moderated since it was on an island in the Bering Sea. Average wind speeds of 7.5 ms^{-1} were reached in the months of January and November for Unalakleet and Northeast Cape respectively. The average wind speeds recorded at Nome were generally lower than the other sites due to periods of O wind velocities caused by orographic blockage and

corner effects. This result and other data (particularly wind direction data) contained in this study indicate that Nome winds should not be used for Bering Sea transport models. Cross correlation values obtained from time series analysis of wind data from the above three stations were significantly less than that obtained in other areas of Alaskan Arctic. This points to a profound influence of orographic and thermal mesoscale effects.

Orographic effects at Nome and Unalakleet were most evident in the winter months. A major factor was cold air drainage down their respective river valleys which were oriented perpendicular to coastlines. Maximum cold air drainage winds recorded at Unalakleet were 16 ms^{-1} and 14.5 ms^{-1} at Nome. This effect alone occurred 20% of the time at Unalakleet in January. Ten percent of all wind velocities recorded at Nome for January and February were zero.

Thermal effects were seen as sea breezes in the Sound during open water water months. The month of greatest occurrence (largest thermal contrast between land and water) was July at both Nome and Unalakleet when pure sea breeze effects controlled 23% of the measured wind velocities. The highest sea breeze velocities reached 10.8 ms^{-1} at both of the sites within Norton Sound during the local afternoons.

A discovery was made when examining summer rotary spectra of station wind time series from Unalakleet and Nome. A mountain valley wind system (combined thermal and orographic effect) was evident at both stations. This system produces up valley winds (enhances shoreward sea breeze flow) from the late morning to evening hours and down valley winds (creates an offshore wind) in the late evening and early morning hours. Therefore, a pseudo summer land breeze can exist in the Arctic producing offshore winds in areas with river valleys. The maximum offshore winds due to this effect (hard to separate onshore sea breeze from onshore mountain valley wind) were 11.32 ms^{-1} at Nome and 10.8 ms^{-1} at Unalakleet and may reach 20 km offshore. Comparison of the network generated geostrophic winds with the coastal site surface winds showed pure orographic effects dominating in the months of total ice cover within the Sound. The thermal effects causing sea breezes and combined thermal-orographic effect of the mountain valley winds dominated in the open water months. The combined mesoscale effects in the open water months of July and August averaged 33% for Unalakleet and 26% for Nome. The geostrophic directions evident from this five year data base study showed that the Yukon Delta would be susceptible to large scale winds pushing contaminants from the west onshore in the open water months. The thermal contrast between the ocean and land would act in a 20 km coastal zone to push contaminants shoreward during weak large scale winds. The Delta does not have the orography to create a mountain valley wind system with periodic offshore winds and has a convex coastline which would further focus the onshore sea breeze effect.

1. Introduction

The prospect of oil development in the Norton Sound area has resulted in recent studies of the wind field both offshore and nearshore with a view to refining predictions of summer oil spill trajectories and winter ice movement. Histograms (Brewer et al., 1977) of surface winds at coastal data sites surrounding the Sound show evidence of thermally driven local winds in the summer blowing toward the site shoreline. In other Alaskan areas Kozo (1982) has shown that sea breeze type winds can dominate a 20 km coastal zone at least 25% of the time during Arctic open water months. Winter surface wind velocity distributions (Brewer et al., 1977) at coastal sites also show obvious orographic effects due to mountain channeling and cold air drainage (Katabatic type). The Sound is considered an ice factory supplying 10 times its area of ice to the Bering Sea (Thomas and Pritchard, 1981). The dominant winter wind directions measured at coastal sites would tend to move ice out of the Sound if these directions truly represented the synoptic wind directions rather than purely local winds.

The Yukon Delta region appears to be one of extreme vulnerability to oil spill and storm surge run-up during open water months. Unfortunately, only limited surface environmental data have been acquired there. Surface pressure data from coastal sites surrounding the Sound (Figs. 1 and 2) could be used to define a useful geostrophic wind to approximate the large scale wind field offshore and near the Delta. The Delta is subject to these synoptic winds with minimal orographic influence, but should have enhanced thermal influence in the summer due to sea breeze wind focusing caused by a convex coastline (McPherson, 1970).

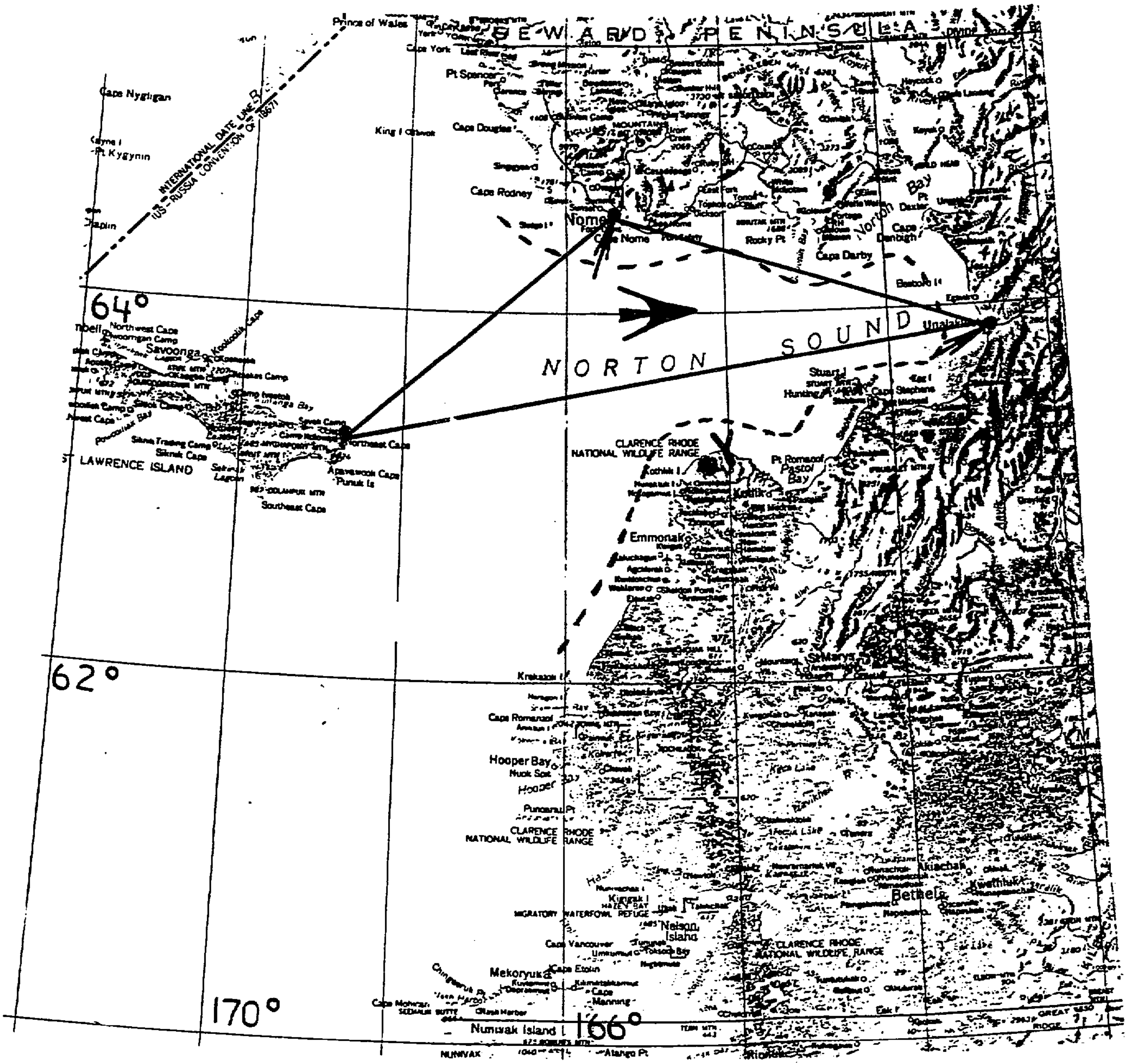


Fig. 1. The triangular surface pressure network formed by the data stations at Nome, Unalakleet and Northeast Cape surrounding Norton Sound. The general summer surface wind directions at Nome and Unalakleet are shown by the small arrows. The general synoptic wind direction is shown by the large arrow. The Yukon Delta tip is designated Y. The dashed line represents the typical extent of mesoscale winds in the nearshore area.

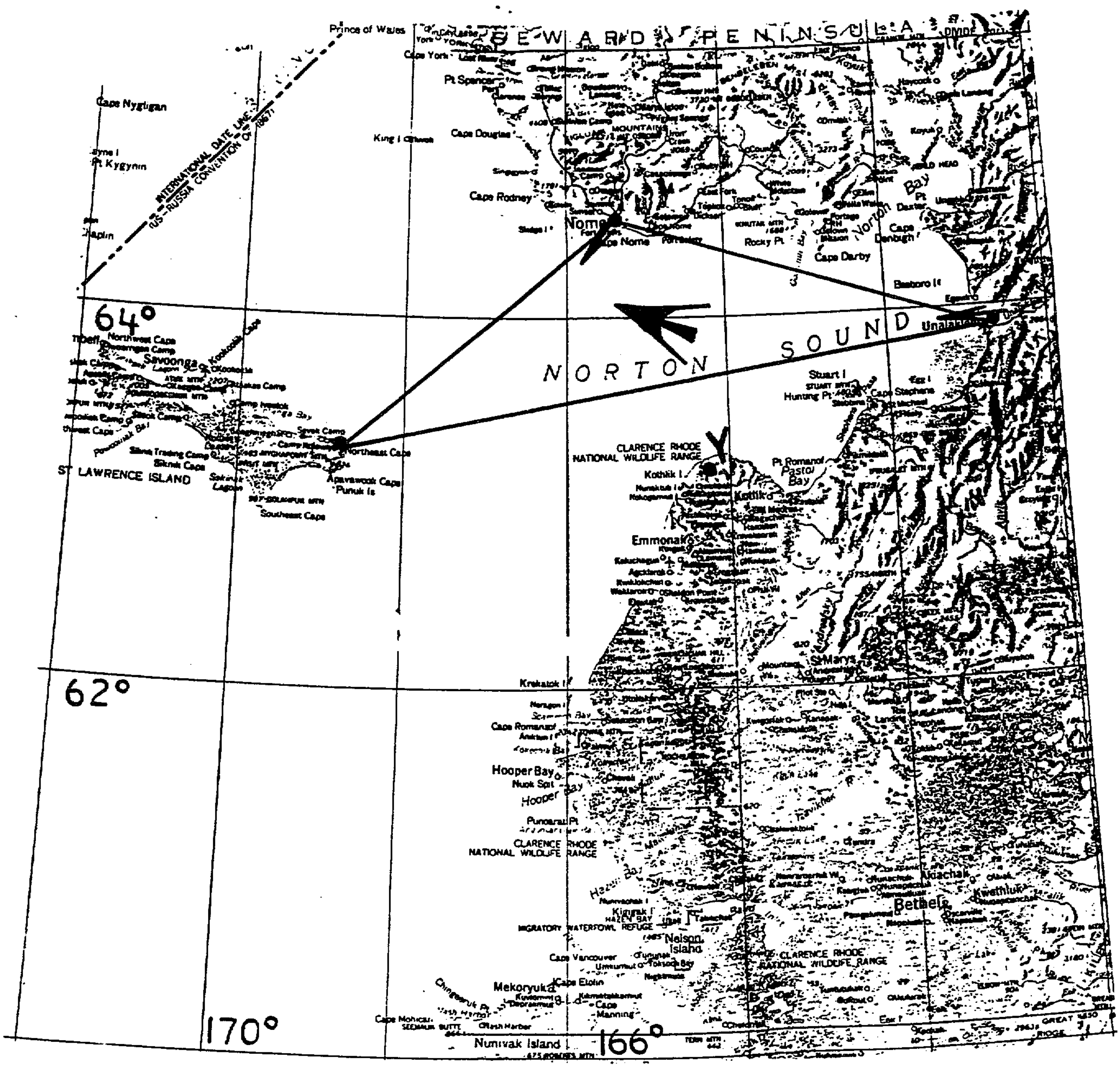


Fig. 2. The same Norton Sound network as Fig. I is shown. The general winter surface wind directions are shown by the small arrowa. The synoptic wind direction is shown by the large arrow. Y representa the tip of the Yukon Delta. The major ice movement in the Sound during winter is due to synoptic winds not local ones.

The problem of differentiating between synoptic wind characteristics which would affect the Sound proper and the measured coastal wind characteristics which are often "contaminated+' by mesoscale effects is always there. This masking (Kozo, 1984) is important in the summer since the thermally induced mesoscale effects perturb the coastal wind statistics and often do not characterize the winds beyond 20 km offshore. Masking is important in the ice covered months because the orographic drainage and corner effect winds (Kozo, 1984) at the coastal sites may be 180° off in direction from the "real" winds in the middle of the Sound which actually . push the ice.

It is easy to see then, that the modeling of oil spill trajectories or ice movement cannot proceed without some offshore wind data or approximations to offshore wind data. Also , the monthly amount of mesoscale modification and threshold velocities for this modification must be quantified if shore station data are to be used in modeling.

2. Study Area

Norton Sound is a "peninsula" of water surrounded by mountains on all but its west flank. It can be seen in Fig. 1 with the general summer large scale wind direction (taken from this study) depicted within the triangle. The dashed line is the approximate seaward distance of onshore push created by sea breezes. The smaller wind arrows at Nome and Unalakleet (two of the three data sites used in this study) show their average summer wind directions. The orientation of the coastline at Nome and the typical onshore sea breeze influence are responsible for the difference in the average measured surface wind direction from the large scale direction.

The synoptic wind and the sea breeze wind are parallel at Unalakleet making pure directional tests bad for separating the two wind types at that site. There are three rivers intersecting at Nome, with at least two associated mountain valley systems to the north. Unalakleet has only one main river with a mountain valley system running east-west. These directions are evident during mountain valley wind events, particularly in the late evening to early morning, due to down valley winds. Y represents the tip of the Yukon Delta with its convex sea breeze focusing coast. Northeast Cape, the third station in our study network, was a United States Air Force Weather Station functioning only during the sixties. This convenient network geometry had not existed again until the eighties when Brown and Caldwell installed a satellite transmitting weather station on St. Lawrence Island for an EXXON sponsored study. Figure 2 shows the general winter large scale wind direction inside the triangle. The smaller arrows at Nome and Unalakleet again show their average wind directions during the winter. There is no sea breeze during this season, but mesoscale effects appear which can mask the real wind directions offshore. The surface station wind data arrows are influenced by cold air drainage through their inland river valleys. Again pure direction tests are not helpful to differentiate local winds from synoptic winds at Unalakleet, but are very revealing for Nome which can have average winds quite different in direction from the large scale winds affecting the Sound proper. Pure blockage of wind by mountain ranges and the corner effects (Kozo, 1984; Dickey, 1961) act to reduce wind velocities at Nome also.

*

3. Data

a. Geostrophic wind data

The wind arrows for the summer and winter in the above figures were computed from barometric pressure and temperature data provided by National Weather Service (NWS) approved stations at Nome, Northeast Cape and Unalakleet from 1964 through 1968. The accuracies of these temperature and pressure data are better than $\pm 1°C$ and $\pm .25$ mb respectively. The atmospheric flow was assumed to be in geostrophic balance (1):

$$f(k \times V) + \frac{\nabla p}{\rho} = 0 \tag{1}$$

The first term is the Coriolis force, the second is the pressure gradient force. f is the Coriolis parameter (1.31×10^{-4} see-l at 64°N), k is the vertical unit vector, V is the velocity vector, Vp is the gradient of the atmospheric pressure and p is the temperature dependent air density. Using the above station grid (Fig. 1) and noting that pressure can be represented as a function of latitude (y) and longitude (x) on a plane surface, the following set of equations:

$$\begin{aligned} P_N(x,y) &= ax_N + by_N + c \\ P_U(x,y) &= ax_u + by_u + c \\ P_C(x,y) &= ax_c + by_C + c \end{aligned} \tag{2}$$

are generated, where the subscripts N, U, and C denote Nome, Unalakleet and Northeast Cape respectively. A matrix solution was applied to solve for the unknowns a, b, and c (Kozo, 1982). Since $\partial P/\partial x = a$, and $\partial P/\partial y = b$, the pressure gradient (VP) can be computed. The geostrophic velocity can now be calculated from (1) since f is known and p for dry air can be estimated from station temperatures. Station temperature errors of $\pm 1°C$ will cause errors of less than 1% in velocity magnitudes since they only affect ρ estimates. With this network geometry (Fig. 1) errors in pressure of $\pm.25$ mb can cause maximum speed errors of 3 ins-l and direction errors greater than $\pm 30°$ for wind speeds below 5 in^{s}-l. Therefore, at wind speeds less than 5 ms^{-1}, wind directions should not be considered significant. Successful use of mesoscale networks to compute geostrophic winds and their increased resolution and predictive capabilities over NWS networks in the Arctic has been documented by Kozo (1980, 1984).

b. Surface wind data

Three hourly surface winds from coastal stations at Northeast Cape, Unalakleet and Nome were used for simultaneous comparison with the calculated geostrophic wind from the same network. Typical accuracies of Arctic type mechanical weather stations are $\pm 1\%$ of full scale (360°) for wind direction and $\pm 2\%$ of the measured value for wind speed (see Kozo 1982). The speed and direction data from Northeast Cape was important since it was out of the Sound proper and represented another “control” for testing the influence of mesoscale effects.

4. Analytical Tools

a. Rotary spectra

Surface wind data from the station network were examined with a rotary spectrum technique (Gonella, 1972). The variance for each frequency band is divided into clockwise (CW) rotating variance (negative frequency) and counterclockwise (CCW) rotating variance (positive frequency). The horizontal surface wind data time series were tested (O'Brien and Pillsbury, 1974) for the appearance of a significant peak on the CW rotating side of a rotary spectral plot corresponding to a one-day period characteristic of sea breezes.

b. Steadiness tests

Tropical trade winds have a steadiness greater than 90%. In the Arctic, wind steadiness tends to increase in the winter ice covered months and decrease in the summer (lower atmospheric stability) months. The definition can be seen in (3) from Halpern (1979):

$$ST = \frac{(\bar{u}^2 + \bar{v}^2)^{\frac{1}{2}}}{(\overline{u^2 + v^2})^{\frac{1}{2}}} \qquad (3)$$

where the numerator is the magnitude of the mean wind vector and the denominator is the mean magnitude. The result is expressed in percent or decimal.

c. Cross correlation and cross spectrum analysis

Standard cross correlation techniques (Panofsky and Brier, 1968) were applied to the time series of wind velocities from the three network stations at both positive and negative time lags. Cross spectral analysis was used to determine whether the above correlations found were due to high frequency or low frequency components. Lastly, coherence tests were made to determine how good the relationship was between the different station wind time series at various significant periods.

d. Bivariate distributions

Tables of computed geostrophic wind directions and simultaneous surface wind directions and speeds were computed to determine mesoscale influences on the large scale wind field. The standard tables of surface wind direction versus surface wind speed were also constructed to match with the tables in Brower et al. (1977).

5. Results with Discussion

a. General characteristics (1964-1968 data)

Figure 3 is a monthly plot of the average wind speeds at Nome (N), Unalakleet (U) and Northeast Cape (C) over a five-year period. Only the key ice covered and open water months have been analyzed. These are January, February, April, May (transition month), July, August and November" (transition month). The open water months showed lower wind speeds. The Nome wind speeds were less than the other two sites due to apparent periods of orographic blockage lasting up to two days (see below).

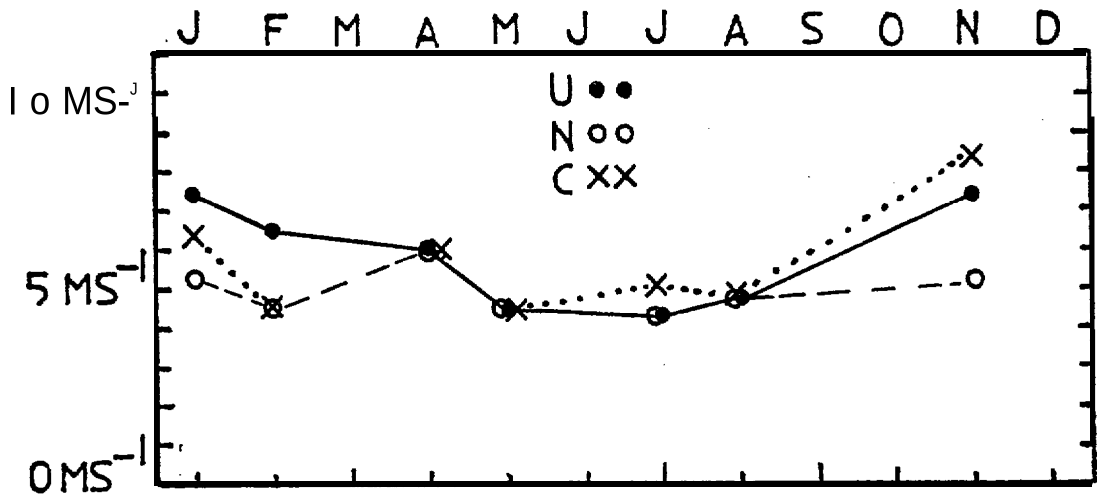


Fig. 3. The monthly average speeds at Nome (N), Unalakleet (U) and Northeast Cape (C) over a five year period (1964-1968).

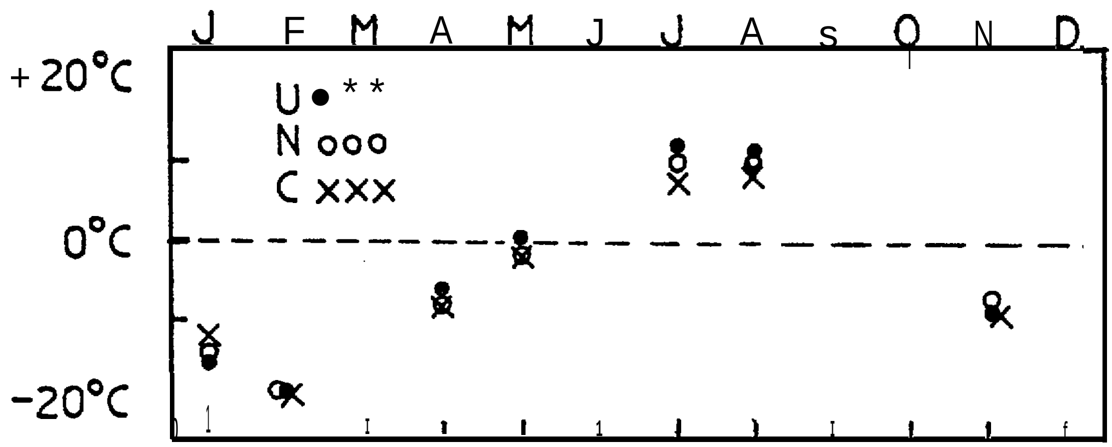


Fig. 4. The monthly average air temperatures for Nome (N), Unalakleet (U) and Northeast Cape (C),

Figure 4 shows a monthly plot of average air temperatures for Nome (N), Unalakleet (U) and Northeast Cape (C). The Northeast Cape temperatures were moderated since the site was on an island surrounded by Bering Sea water.

Figure 5 shows the steadiness (decimal equivalent) of the surface winds at the three designated study sites. The winds in the site vicinity were most steady when their respective offshore areas were ice covered. The ice covered months for Nome and Unalakleet were November through April while Northeast Cape was surrounded by ice from December through May (see Figs. 6 and 7). May and November represent periods of transition from solid ice cover to open water and open water to solid ice cover respectively. Unalakleet and Nome have a high steadiness (Fig. 5) in the winter months aided by orographic channeling but a low steadiness in the summer months due to the thermal contrast at the coast and mountain valley winds (see below). Northeast Cape is on a "tiny" peninsula with no preferred coastal orientation to produce a definite sea breeze direction or large system of mountain ranges to channel winds. It does, however, have some very local wind characteristics that are beyond the scope of this study.

Figure 8 is a plot of highest (lags from 0 to 15 hours) cross correlation values for time series of wind velocity data from land surface wind stations versus distance (km) of separation. The solid line was developed for stations on the Chukchi and Beaufort coasts as well as islands in the Bering Sea. None of these sites were subject to significant orographic modification, but all were subject to sea breeze effects. The coastlines of these previous land sites were usually parallel however, which improved the chances for higher correlations at 0 lags when synoptic winds were weak. The dashed line represents cross correlations between wind data from Nome and Northeast Cape (N-C), Northeast Cape and Unalakleet (C-U), and

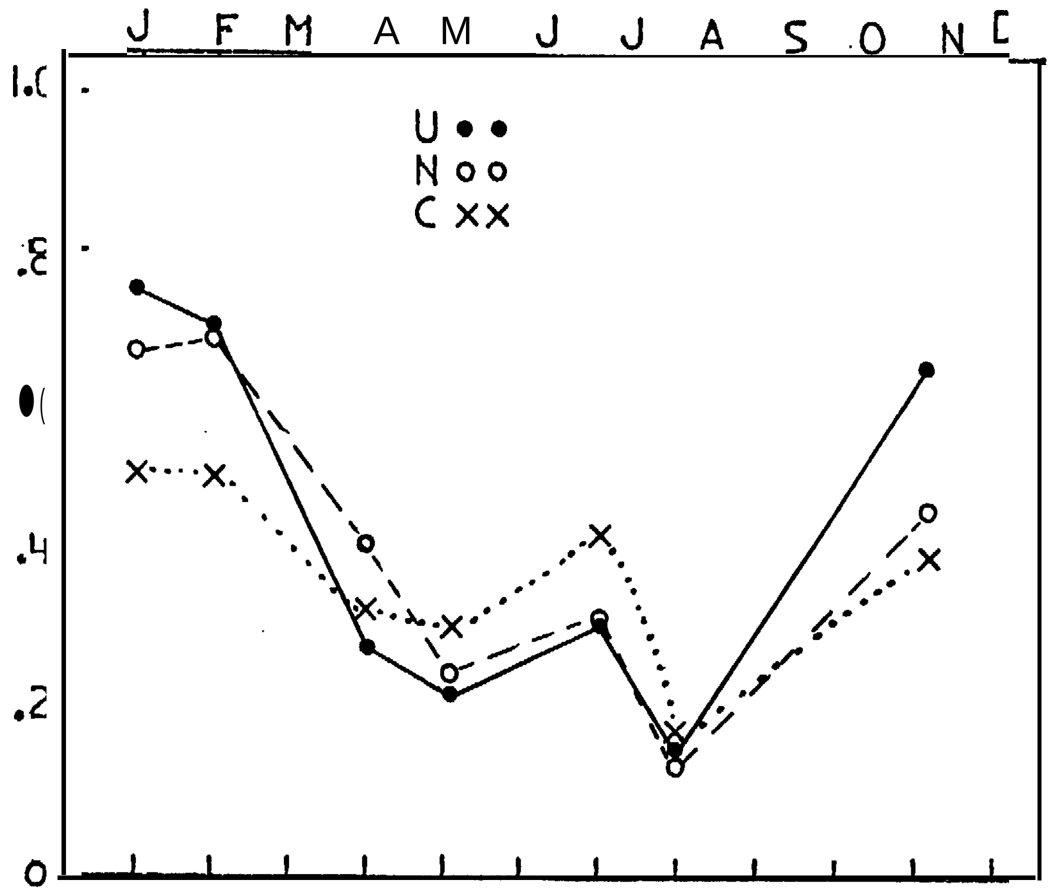


Fig. 5. Steadiness (decimal equivalent) of the surface winds at Unalakleet (U), Nome (N), and Northeast Cape (C).

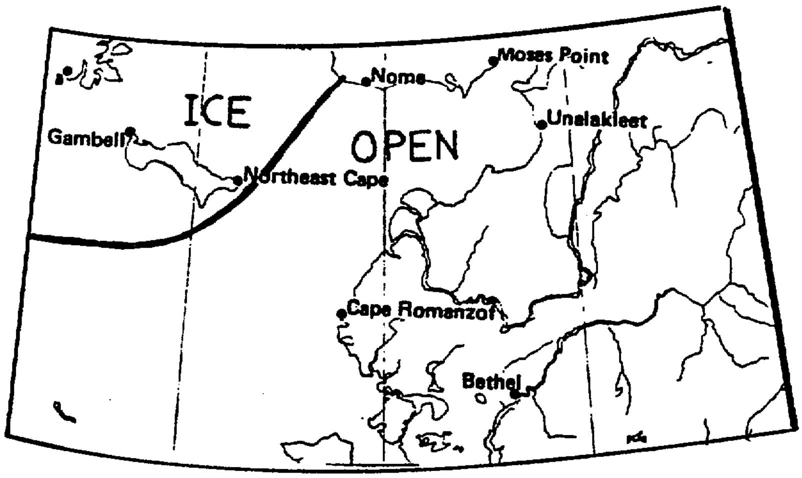


Fig. 6. Average position of the ice edge in May (from Brewer et al., 1977).

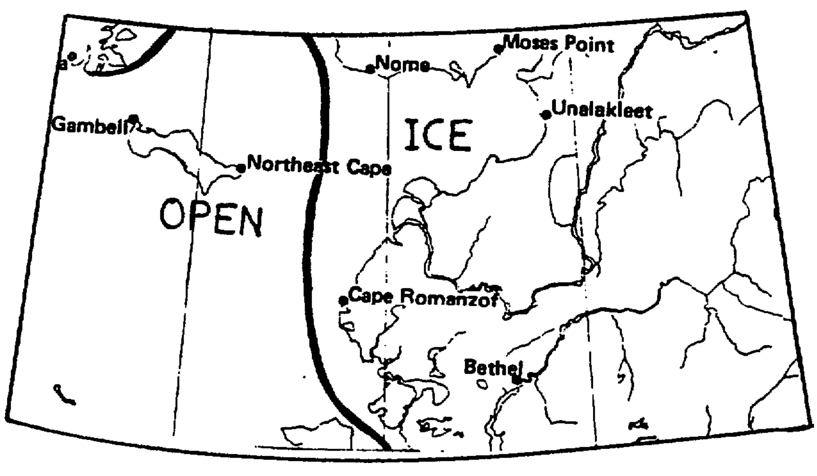


Fig. 7. Average position of the ice edge in November (from Brewer et al., 1977).

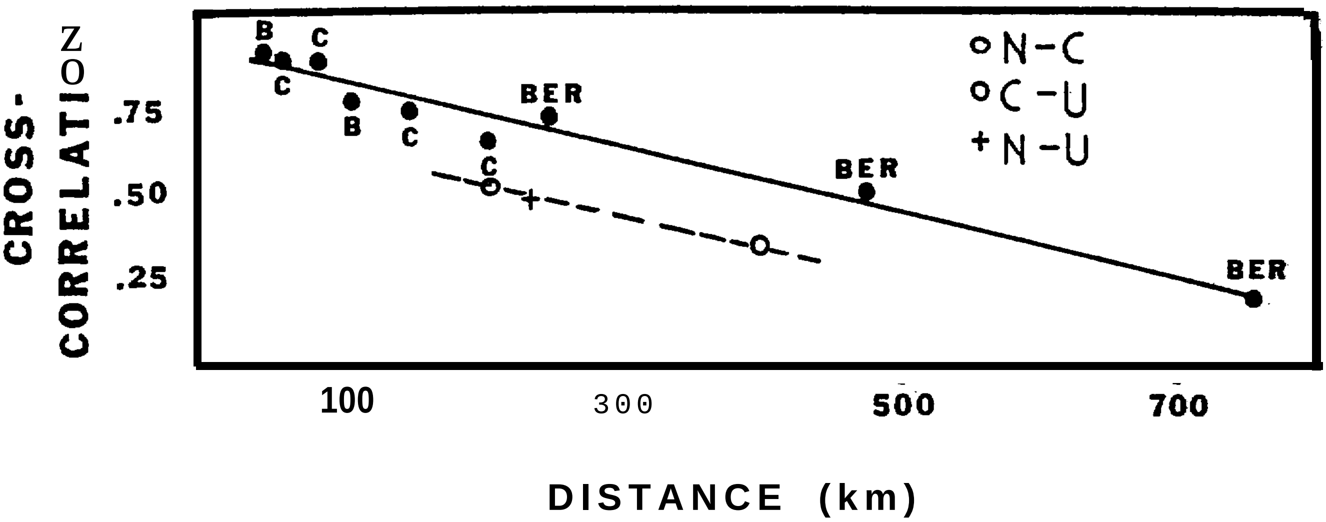


Fig. 8. Cross correlation values for time series of wind velocity data from land surface wind stations versus distance of separation. The solid line was developed for stations on the Chukchi and Beaufort coasts as well as islands in the Bering Sea. The dashed line represents cross correlation wind data between Nome and Northeast Cape (N-C), Northeast Cape and Unalakleet (C-U), and Nome and Unalakleet (N-U).

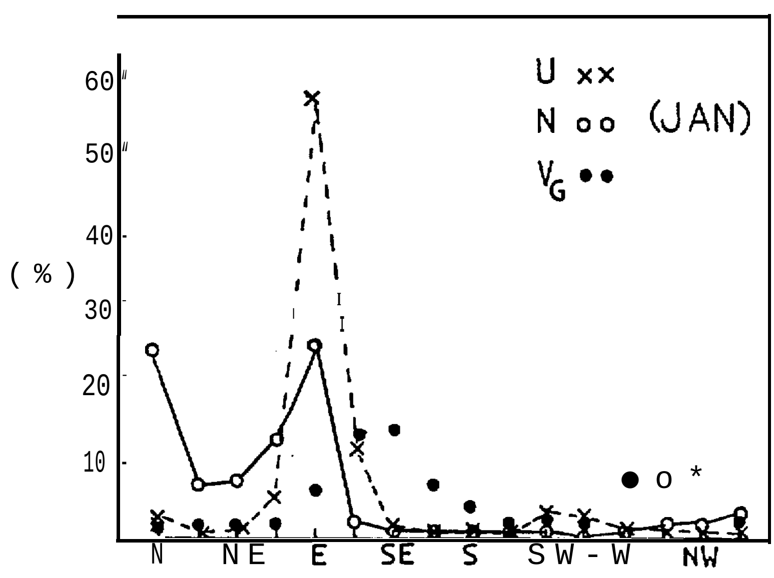


Fig. 9. The average percentage directional distribution of the Nome (N), Unalakleet (U) and the calculated geostrophic (V_g) winds in January (1964-1968).

Nome and Unalakleet (N-U). The correlation values are much lower than those previously obtained in other parts of the Alaskan Arctic. The influence of perpendicular coastline orientations (summer), perpendicular river valley cold air drainage systems (mainly winter) and preferred mountain blockage directions (winter) can easily be seen. Their effects on modifying the synoptic wind in the area are profound.

b. Large scale versus mesoscale winds

The geostrophic wind field in the Norton Sound area due to the atmospheric pressure gradient was calculated using standard techniques. The effect of land or water surface friction on this geostrophic wind should be a reduction in speed and 20°-300 of CCW turning from the calculated direction (Kozo, 1984). Any turning of surface winds greater than this is a good indication of mesoscale influence. The surface winds at Nome and Unalakleet were compared simultaneously to the above calculated large scale wind to make quantitative estimates of these effects.

Table 1 is an extreme example of what winter orographic effects can do to the wind. In January 1966, 86% of the Unalakleet wind directions recorded were from 78.5° to 101.0° along with the highest wind speeds. Table 2 shows geostrophic wind (Vg) directions compared to simultaneous Unalakleet surface wind directions (Us). The Vg direction distribution shows a large percentage of winds from at least four directions (78.5°-1010, 101°-123.50, 123.5°-1460, and 1460-168.50). The apparent wind turning from the calculated geostrophic direction to the surface is CW rather than “normal” CCW frictional turning and often more than 45° for a large number of cases. At least 30% of the surface winds in the 78.5°-1010 sector were due to some type of orographic

S P E E D (ms-1) (obs. 248)

DIRECTION	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	TOTAL	PER
326.0-348.5	0	0	0	0	0	0	0	'a	0	0	0	0	0	0	0	0	0.0
303.5-326.0	0	0	0	0	a	0	0	0	0	0	0	0	0	0	0	0	0.0
281.0-303.5	0	0	a	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
250.5-201.0	0	0	Q	0	0	0	0	Q	0	0	0	0	0	0	0	0	0.0
236.0-258.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
213.5-236.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.Q
191.a-213.5	0	0	0	0	0	0	0	0	0	0	a	0	0	0	'a	0	a.0
168.5-191.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
146.0-160.5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.'a
123.5-146.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
101.0-123.5	0	1	0	1	1	0	a	0	ii	0	0	0	0	0	0	3	1.0
78.5-101.0	1	5	5	13	35	74	62	12	3	4	0	0	0	0	0	214	86.0
56.0-7a.5	0	1	3	4	8	11	1	1	0	0	0	0	0	0	0	29	11.0
33.5-56.0	a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
11.0-33.5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	Q	1	0.0
348.5-11.a	0	0	0	0	0	a	0	0	0	0	0	0	0	0	0	0	0.0

Table 1 Bivariate distribution of wind direction versus wind speed data (three hourly) for Unalakleet, Alaska in January, 1966. Winds above 14 ms^{-1} are considered gale class.

DIR EC TION (US) (ohs. 248)

a I R C T I O N Vg-

	0.0	11.0	33.5	56.0	78.5	101.0	123.5	146.0	168.5	191.0	213.5	236.0	256.5	281.0	303.5	326.0	TOTAL	PER
326.0-348.5	0	0	0	1	5	0	0	0	0	0	0	0	e	0	0	0	6	2.0
303.5-326.0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0.0
261.0-303.5	0	0	0	1	2	1	0	0	0	0	0	0	0	0	0	0	4	1.0
258.5-291.0.	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	5	2.0
236.0-258.5	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	2	0.0
213.5-236.0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3	1.0
191.0-2! 3.5	0	0	0	0	3	0	0	0	0	a	0	0	e	0	0	0	3	L 0
168.5-191.0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	4	1.0
146.0-168.5	0	0	0	0	19	0	0	0	0	0	Q	0	0	0	0	0	19	7.0
123.5- 146.0	0	0	0	6	59	0	0	1	0	0	0	0	0	0	0	0	66	26.0
101.0-123.5	0	1	0	9	72	2	0	0	0	0	0	0	0	0	0	0	84	33.0
78.5-101.9	0	0	0	4	27	0	0	0	0	0	0	0	0	0	0	0	31	12.0
56. 0- 10.5	0	0	0	3	4	u	0	0	0	0	0	0	0	0	0	0	7	2.0
33.5- 56.0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3	1.0
11.0- 33.5	0	0	0	2	4	0	0	0	0	0	0	0	0	0	0	0	6	2.8
340.5- 11.0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	3	1.0

Table 2. Bivariate distribution of calculated geostrophic winds (Vg) versus Unalakleet simultaneous surface winds (Us) for January, 1966. Horizontal directions represent the same sectors as the vertical except that O is the middle of the 348.5°-11.00

channeling. The extent of these winter effects in other years (1964-1968) can be seen in January bivariate distribution tables (Appendix A) for Unalakleet and Nome. Table 3 is a bivariate distribution of wind direction versus speed at Unalakleet for July, 1967. This Unalakleet wind distribution is similar to those shown in Brewer et al. (1977) in the summer months. The summer mesoscale effects on the surface wind are due to the thermal contrast at the coast, the decrease in atmospheric stability with land warming, and mountain valley combined orographic-thermal phenomena. The distribution shows the typical increase in onshore winds over that of the winter months and also a decrease in frequency of easterly winds. Table 4, however, shows that 24% of the recorded surface SW to NW winds at Unalakleet occur simultaneous to geostrophic winds from 56° to 168°. Again, this “turning” of the geostrophic wind at the surface is CW rather than CCW and often greater than 45°. The extent of these summer effects in other years (1964-1968) can be seen in July bivariate distribution tables (Appendix A) for Unalakleet and Nome. As in winter, the surface wind histograms do not show the true large scale wind distribution which would be the major factor in surface pollutant and ice floe movement in the Sound proper.

Figure 9 shows a percentage directional distribution of the winds for Vg, Nome (N) and Unalakleet (U) in January (average of the years 1964-1968). The Vg distribution has a SE peak and a wide peak in W to NW winds. Again, the great dominance of the easterly winds at Unalakleet can be seen. As explained above, the combination of synoptic wind direction, channeling of winds and pure cold air drainage down a main river valley act to produce this unimodal distribution at Unalakleet. The directional distribution for Nome has two “bumps”. The winds from the east are mainly large scale (synoptic), but those from the north are mesoscale in origin again caused by cold air

S P E E D (ins-l) (ohs. 248)

DIRECTION	0- 2	2- 4	4- 6	6- 8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	TOTAL	PER
326.0-348.5	0	1	3	3	0	a	0	a	a	a	a	a	0	0	0	7	2.a
303.5-X6.8	0	4	7	2	0	0	0	0	a	0	0	0	a	0	0	13	5.0
28100 -303.5	1	5	6	1	0	a	0	a	a	0	0	0	0	0	0	13	5.0
259.5-:81.0	0	8	22	10	2	8	1	1	0	0	a	a	a	0	0	52	2a.a
236.0-2:8.5	1	6	16	12	7	8	2	0	0	a	a	a	0	0	a	52	26.0
213.5-236.0	1	4	4	10	14	0	1	a	0	0	0	0	a	0	0	34	13.0
191.0-?13.5	0	2	2	5	1	0	0	0	a	0	0	0	a	0	a	10	4.a
168.5-191.0	1	5	4	2	2	0	0	0	a	0	a	0	0	0	a	14	5.a
146.a-l68.5	1	i?	1	0	0	a	0	0	a	0	0	0	a	0	a	4	1.0
123.5 -146.0	0	4	2	2	1	0	0	0	0	0	0	0	0	0	0	9	3.a
101.0-123.5	1	9	3	0	0	0	0	a	a	a	0	a	a	a	0	13	5.a
78.5-101.0	1	9	6	1	0	0	0	0	a	0	a	0	a	a	0	17	6.0
56.0- 7a.5	0	1	1	0	0	0	0	0	0	0	0	0	a	0	0	2	0.a
33.5- 56.0	0	0	1	0	0	a	0	0	0	a	a	0	a	a	0	1	0.a
11.0- 33.5	0	a	a	0	0	0	0	0	0	a	a	a	0	0	0	a	0.a
348.5- 11.0	5	2	a	0	0	a	0	a	a	a	0	0	a	a	0	7	2.a

Table 3. Bivariate distribution of wind direction versus wind speed data (three hourly) for Unalakleet, Alaska in July, 1967. Winds shove 14 ms^{-1} are considered gale class.

DIRECTION (Us) (248 obs.)

DIRECTION (Vg)

	0.0	11.0	33.5	56.0	78.5	101.0	123.5	146.0	168.5	191.0	213.5	236.0	258.5	281.0	303.5	326.0	TOTAL	PER
326.0-348.5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0.0
303.5-326.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
281.0-303.5	0	0	0	0	1	2	0	0	1	1	5	3	6	3	1	0	23	9.0
258.5-281.0	3	0	0	0	0	0	0	1	1	2	4	5	5	0	0	0	21	8.0
236.0-258.5	0	0	0	0	0	0	1	0	1	2	9	16	4	0	0	0	33	13.0
213.5-236.0	0	0	0	0	0	1	3	0	1	2	2	6	7	0	0	0	22	8.0
191.0-213.5	0	0	0	0	0	1	1	1	1	2	2	3	6	1	0	0	18	7.0
168.5-191.0	1	0	0	0	0	2	2	0	2	1	6	8	4	1	0	0	27	10.0
146.0-168.5	1	0	0	0	1	1	1	0	5	0	3	2	2	2	0	1	19	7.0
123.5-146.0	1	0	0	2	6	5	0	1	2	0	2	2	3	1	1	2	28	11.0
101.0-123.5	1	0	1	0	6	1	0	0	0	0	1	2	5	1	4	1	23	9.0
78.5-101.0	0	0	0	0	1	0	0	0	0	6	0	3	6	2	4	0	16	6.0
56.0- 78.5	0	0	0	0	0	0	0	0	0	0	0	1	3	1	2	2	9	3.0
33.5- 56.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
11.0- 33.5	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	3	1.0
348.5- 11.0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	1	1	5	2.0

Table [illegible] Bivariate distribution of calculated geostrophic winds (Vg) versus Unalakleet simultaneous surface winds (Us) for July, 967. Horizontal directions represent the same sectors as the vertical except that 0 is the middle of the 348.5° - 11.0° sector instead of the minimum direction value.

drainage down its main river valley (runs north and south), channeling, and corner effects (Dickey, 1961). These corner effects will redirect winds and will produce simultaneous wind speeds that are supergeostrophic or almost zero depending on the large scale wind direction and orographic obstacle orientation. The monthly percentage occurrence of two types of corner effects (Fig. 10) can be seen at Nome and Unalakleet. These were measured zero winds (Nome [NB], Unalakleet [UB]) and supergeostrophic winds (Nome [NSG], Unalakleet [USG] for cases where Vg was greater than 6 ms‘l. The months with the Norton Sound completely ice covered and greatest atmospheric stability show the greatest occurrence of corner effects. The monthly percentage (Fig. 11) of cold air drainage (CAD) winds at Nome (NCAD) and Unalakleet (UCAD) is highest in the winter months when the sound is ice covered. However, the summer mountain-valley wind system will produce a high percentage of CAD during its night time cycle (see below). Pure CAD winds were observed during Vg speeds below 5 in^{s}-l. The highest CAD wind speeds measured were 14.5 ins-l and 16 ins-l at Nome and Unalakleet respectively in the winter. These were higher than the maximum CAD winds associated with summer mountain valley winds because daylight hours were minimal and no thermal contrast existed at the coast to cause a flow reversal.

Figure 12 shows the average percentage directional distribution of winds for Vg, Nome (N) and Unalakleet (U) in July (years 1964-1968). Vg has a broad SW to W peak. Unalakleet has a small east peak and a broad peak in the SW to W sectors. Nome has a peak in the North, South and SW-W sectors. There is no striking dominance of direction as seen in Fig. 9. The east peak in the Unalakleet and north peak in the Nome distributions are ❑airily due to CAD from their respective mountain valley systems (see Fig. 13). The maximum CAD winds in the summer reached 11.3 ins-l and 10.8 ins-l at Nome and

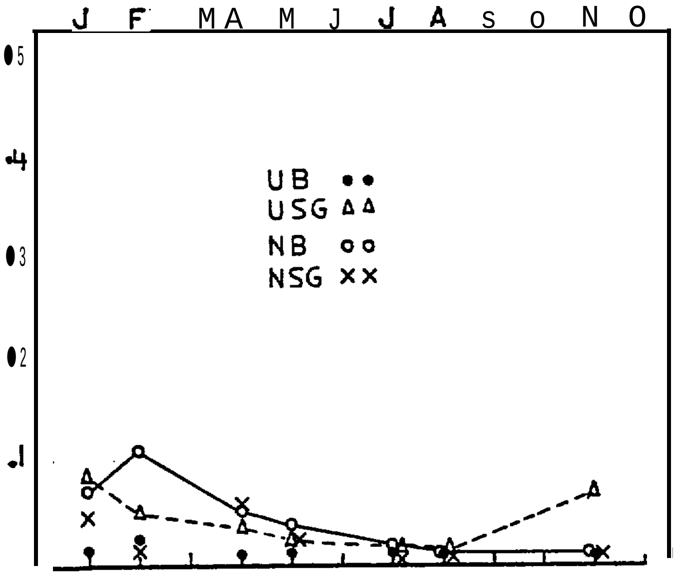


Fig. 10. The average percentage of occurrence for two typea of corner effects at Unalakleet (U) and Nome (N). Seven months are shown for the 1964 to 1968 time period. The zero wind speed cases are designated B and the supergeostrophic wind cases are designated SG.

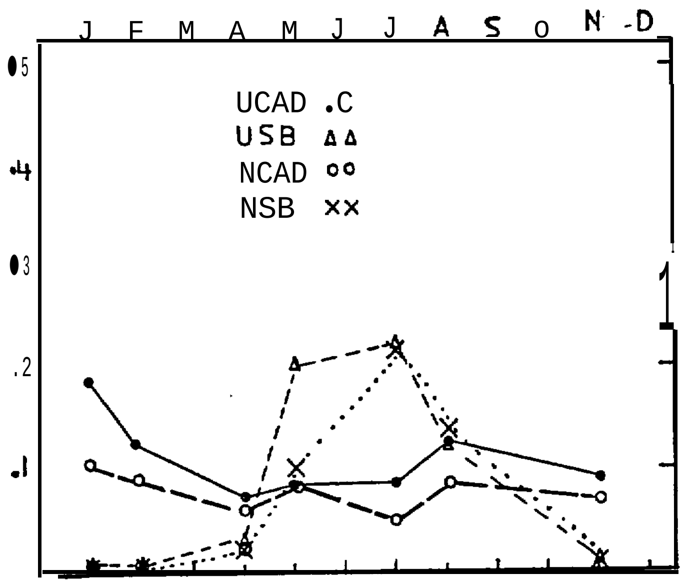


Fig. 11. The average occurrence percentage of cold air drainage (CAD), winds and sea breeze (SB) winds at Nome (N) and Unalakleet (U). Seven months are shown for the 1964 to 1968 time period.

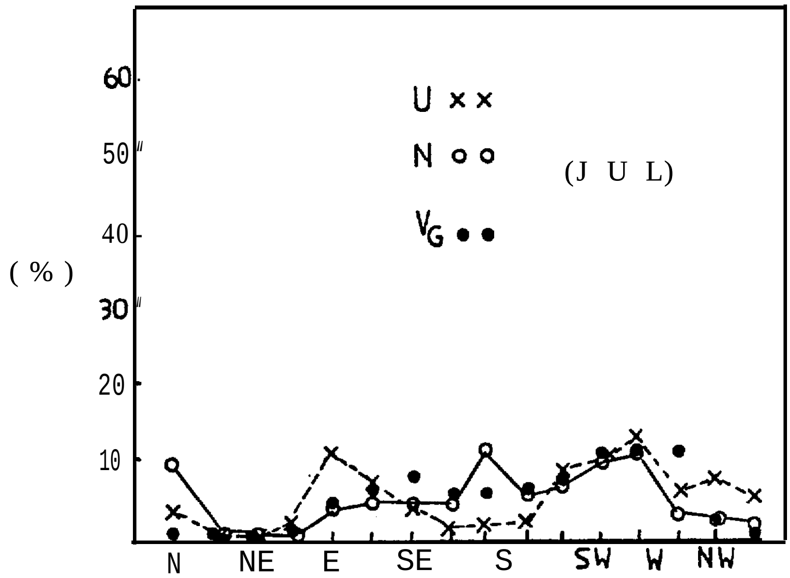


Fig. 12. The average directional distribution (%) for Nome (N), Unalakleet (U) and 'he calculated geostrophic (Vg) winds in July (1964-1968).

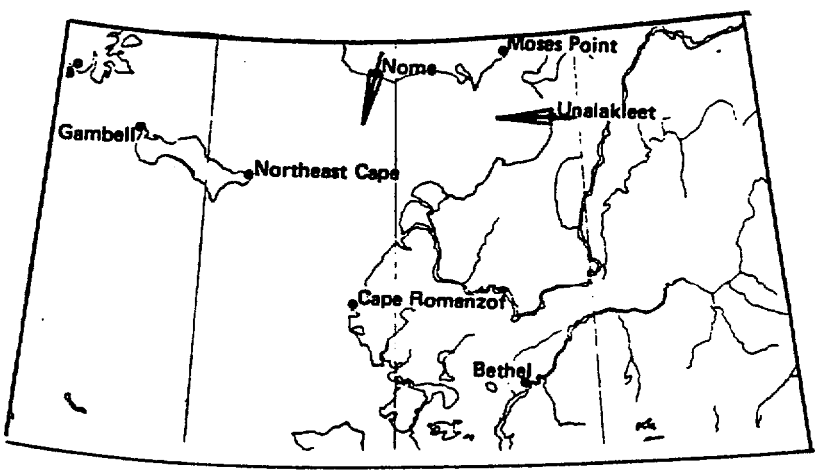


Fig. 13. Major directions of offshore winds due to cold air drainage at Nome and Unalakleet.

Unalakleet respectively. The south peak in the Nome data is due to sea breeze influence, but for Unalakleet both the surface distribution and the Vg distribution have west peaks. However, using a simple speed test, the sea breeze influence at Unalakleet can be discerned if coastline orientation is remembered. When Vg is less than 5 ms^{-1} the afternoon winds at Nome are usually from the south while the winds at Unalakleet are from the west. Figure 14 is an idealized case of this which leads to the conclusion that sea breeze winds will come from the NW at the Yukon Delta (lowest arrow) a region that will produce limited mitigating orographic effects. Figure 11 (above) also shows the monthly percentage of sea breeze effects at Nome (NSB) and Unalakleet (USB). The open water months are the obvious periods of high sea breeze incidence which can occur as early as May. The highest sea breeze winds ❑ easured (1964-1968) during low speed synoptic wind cases were 10.8 ins-l at both Nome and Unalakleet. This casts doubt on the 15 ins-l sea breeze speeds in Norton Sound observed by Robin Muench (SAI, personal communication) and reported in Zimmerman (1982). The synoptic winds were probably onshore at the time and the observers assumed that they were sea breezes.

Figure 15 shows the average percentage of the combined mesoscale effects due to mountain valley wind systems, sea breeze wind systems, corner effects and pure cold air drainage at Nome and Unalakleet (1964-1968) in seven study ❑ onths. Nome and Unalakleet usually experience mesoscale dominated winds more than 20% of the time with Unalakleet reaching 30% in the winter and summer. Again these effects will hide the real wind stress directions in the sound proper and near the Yukon Delta. The offshore distance of influence for sea breeze (Kozo, 1982) and CAD winds (Reynolds, 1980) in the Arctic open water season is at least 20 km. The sea breeze produces onshore flow while CAD winds produce offshore flow. The above evidence is further proof that

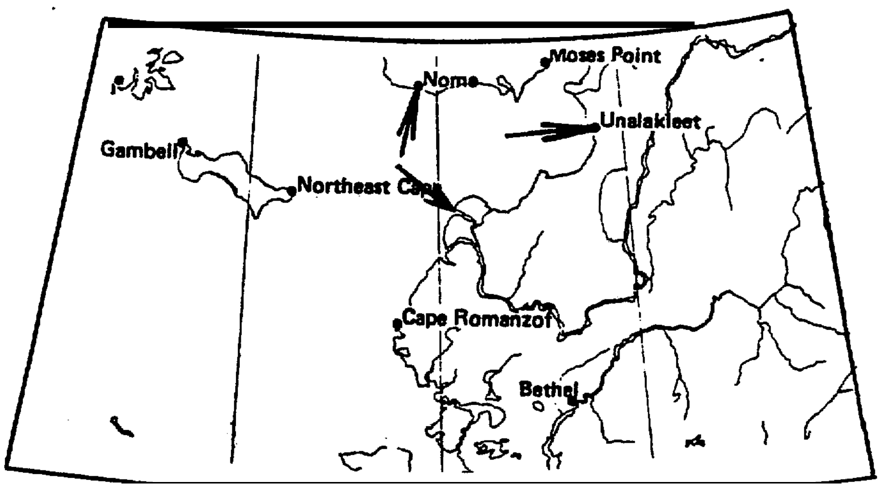


Fig. 14. Major directions of onshore winds due to ses breeze influence at Nome and Unalakleet. The probable direction of these winds at the Yukon Delta is shown at the lowest arrow.

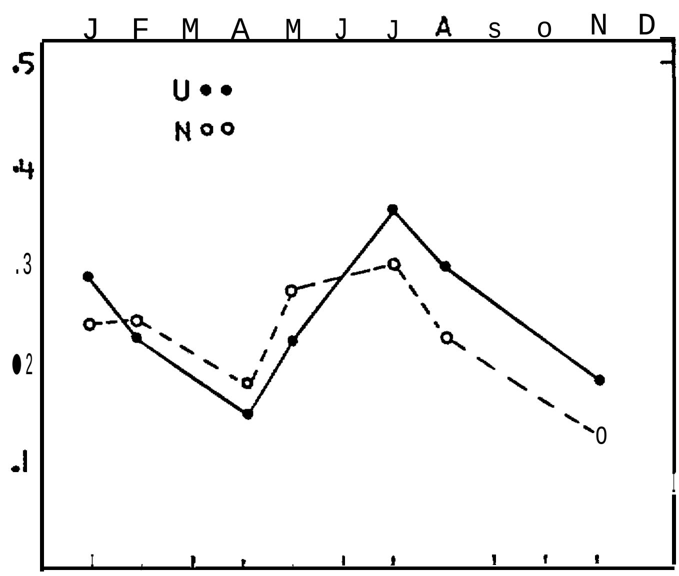


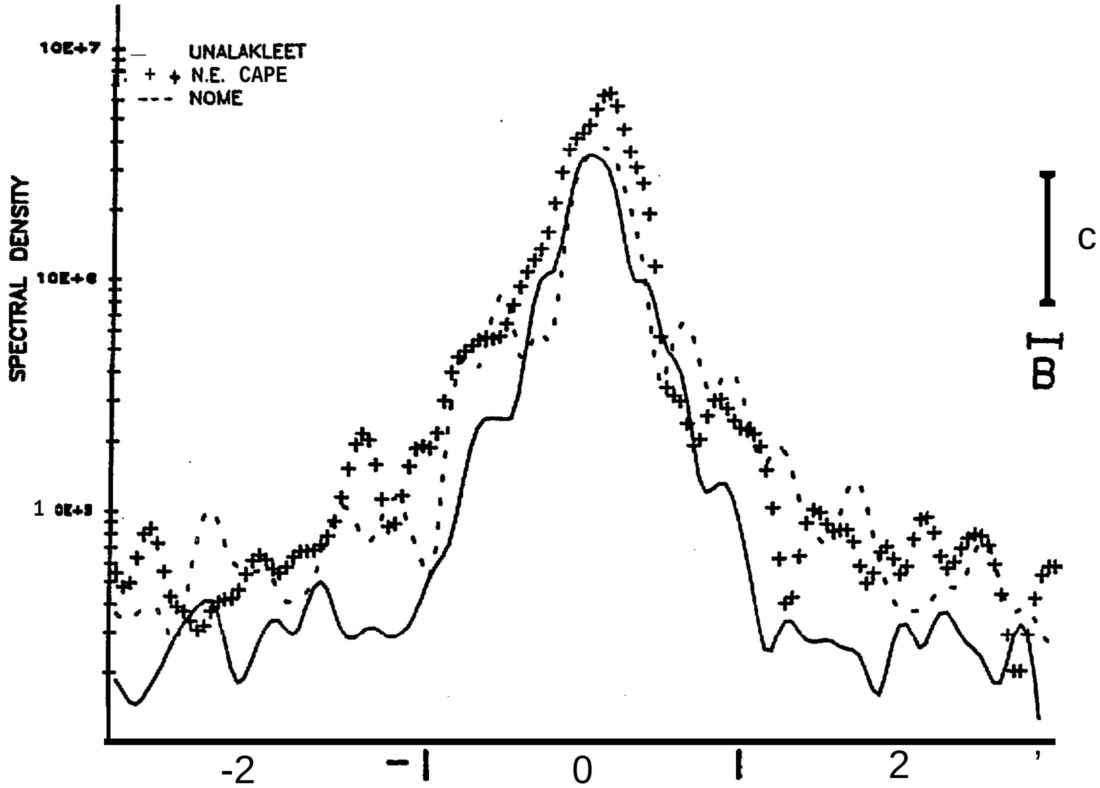
Fig. 15. The total amount of monthly mesoscale influence provided by mountain valley winds, sea breezes, corner effects and pure cold air drainage combined for Nome and Unalakleet (1964-1968).

time series data of winds from Nome should not be used in oil spill trajectory models without extensive modification.

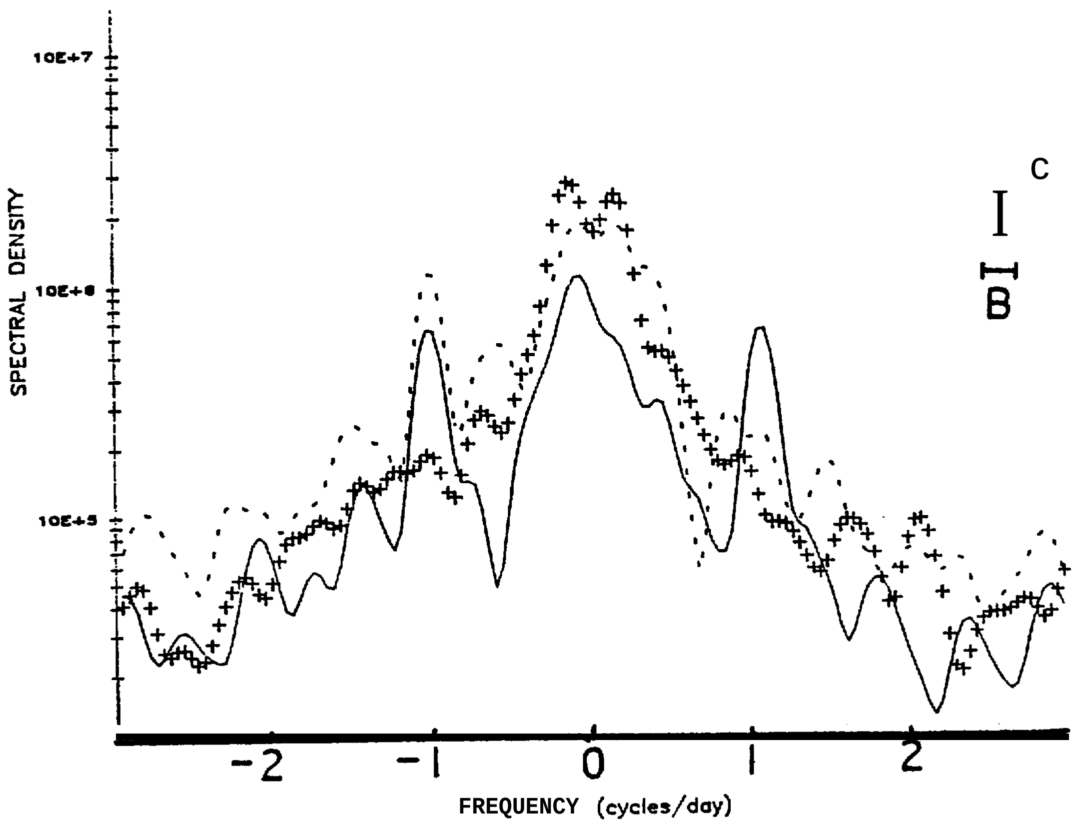
c. Analysis of surface wind time series

Semi-log plots of January 1964 (Fig. 16a) and July 1964 (Fig. 16b) rotary spectra from time series data at Unalakleet, Northeast Cape and Nome are shown with 95% confidence limits (C) and bandwidth (B) indicated. The vertical axes are in units of spectral density (m^2s^{-2} per cycle $[3h]^{-1}$) with the horizontal axes in frequency units of cycles day-l. Figure 16a (January, 1964) does not have significant peaks at mesoscale frequencies and shows dominance by low frequency synoptic wind systems for all three station locations. Figure 16b (July, 1964) is characteristic of most of the summer spectral plots for the five-year data set. Rotary spectra plots for the transition months of May, 1968 (Fig. 17a) and November, 1968 (Fig. 17b) are also shown. May, the first open water month in the Sound (Fig. 6) has curves with the same characteristics as those of July (Fig, 16b) for all three stations. The -1 and +1 cycle day^{-1} peaks are not as pronounced since the May land temperatures (Fig. 4) are not as high. November, the first ice covered month (Fig. 7) after summer, has curves with no significant ❑esoscale peaks at any of the three stations. This was also characteristic of the January curves (Fig. 16a) and shows the effects of total ice cover and lack of daylight. The spectral plots for January-July and May-November in the years 1964-1968 can be seen in Appendix B.

There are several important features to notice in the open water spectral plots (Fig. 16b and 17a). The first is the general absence of significant peaks in the Northeast cape curve (dashed line). The second is the significant peak on the negative frequency side of the spectrum at -1

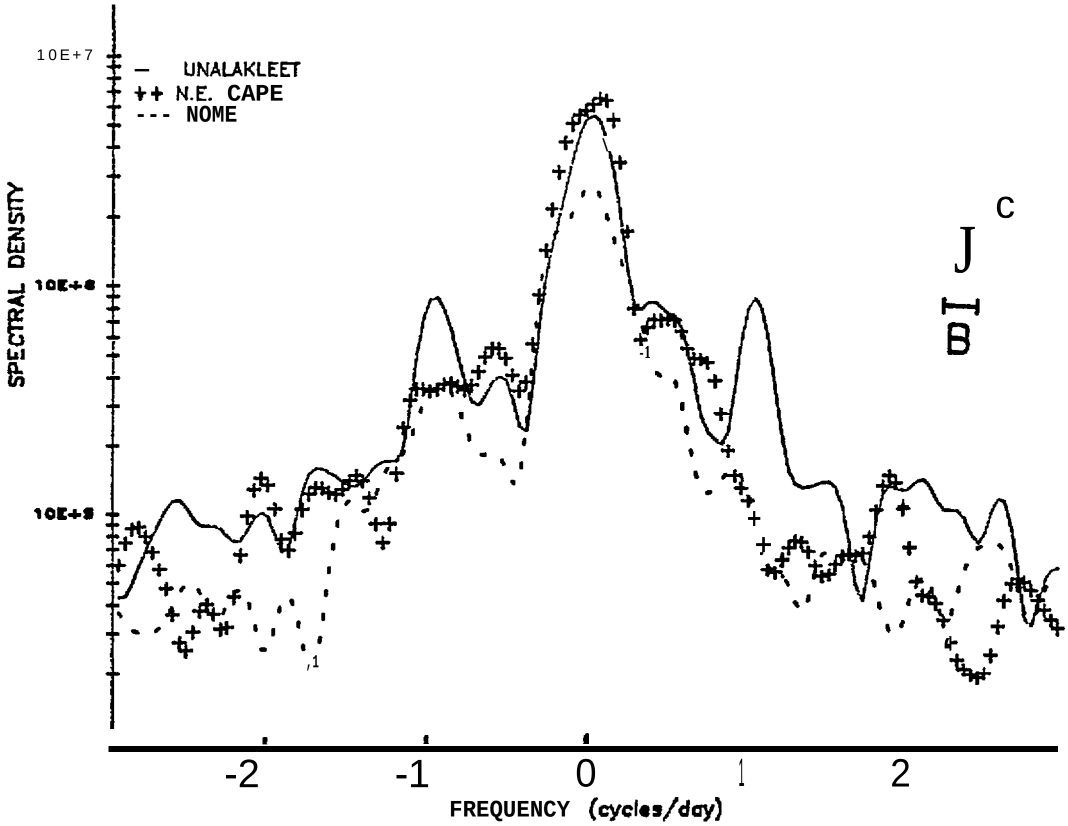


(a)

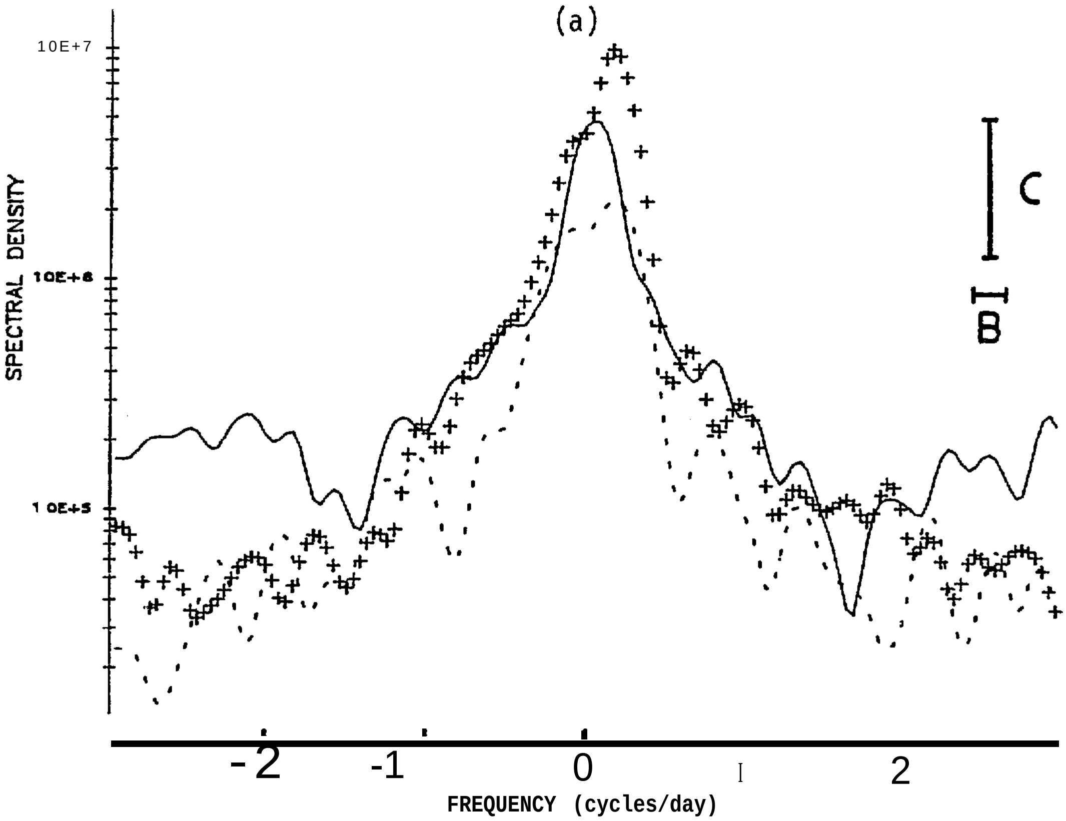


(b)

Fig. 16. Time series rotary spectra of surface wind velocity data from Unalakleet, Northeast Cape, and Nome for (a) January, 1964 and (b) November, 1968.



(a)



(b)

Fig. 17. Time series rotary spectra of surface wind velocity data from Unalakleet, Northeast Cape, and Nome for (a) May, 1968 and (b) November 1968.

cycle day^{-1} for both Unalakleet (solid line) and Nome (dashed line). The third is the significant peak on the positive frequency side at +1 cycle day^{-1} for both Unalakleet (solid line) and Nome (dashed line). The fourth is that the variance (energy) represented in the negative and positive diurnal peaks (mesoscale) is close to that of the central synoptic peak (July in particular).

The absence of peaks in the Northeast Cape curve indicates that the data station had no dominant coastal orientation to set up ideal sea breeze type winds. The Northeast Cape curve in other years is not usually this “clean”, however. The negative frequency peaks at -1 cycle day^{-1} for Unalakleet and Nome are characteristic of Arctic sea breeze effects on surface wind data (Kozo, 1982). Figure 18 is a monthly plot of coherence (five year data set average) between winds at Nome and Unalakleet for -1 day periods (sea breeze period). The dashed line represents the coherence at the 1% limit for 10 degrees of freedom which characterize the monthly data sets. The two stations are strongly linked by sea breeze effects during the warmest open water months of July and August. The chances are 1 in 100 that these stations are related by accident at this one day period. Remember, however, that the sea breeze wind direction at Unalakleet will be ideally 90° from the sea breeze direction at Nome (Fig. 14).

The significant positive frequency peaks (CCW wind vector rotation) seen in the rotary spectra from Figs. 16b and 17a have not appeared on previous data analyses of other Alaskan Arctic coastal sites (Kozo, 1984) and they do not appear on Northeast Cape spectra either.

The Nome and Unalakleet data sites have river valleys which are perfect for mountain valley wind systems that are generated by combined orographic and thermal mesoscale conditions. Figures 19 (a-h) illustrate (Fairbridge,

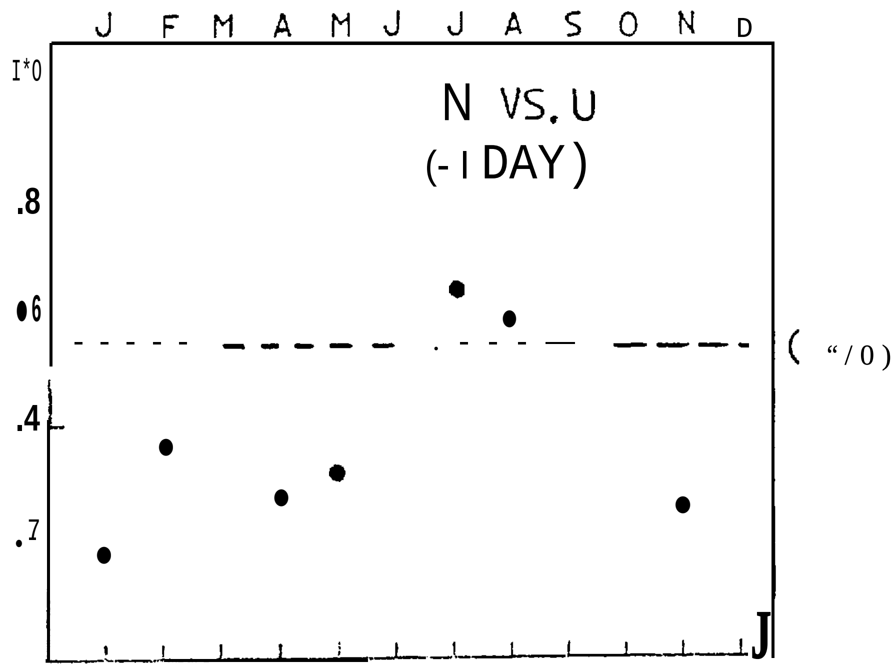


Fig. 18. The average monthly coherence (1964-1968) between sea breeze winds at Nome and Unalakleet. These winds have a one day period on the CW (-) side of spectral plots such as seen in Figs. 16 and 17. The dashed line represents the 1% coherence limit for 10 degrees of freedom.

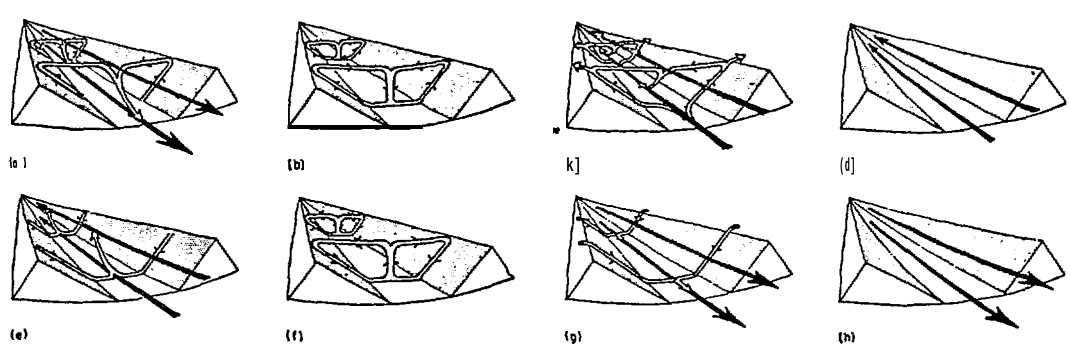


Fig. 19. The normal diurnal variation of air currents in a valley (Fairbridge, 1967). (a-h): a. sunrise--onset of upslope winds (white arrows) and the continuation of mountain drainage winds (black arrows); b. forenoon--transition from down mountain to up valley winds; c. early afternoon--the fully developed valley wind with diminishing slope winda; d. late afternoon--the valley wind; e. evening--the beginning of downslope winds and a diminishing valley wind; f. early night--the transition from valley to mountain winda ahowing well-developed downslope winds; g. middle of the night--continuing downslope winds and fully developed mountain winds; h. late night to morning--downslope winds ceasing with full mountain winda.

1967) the normal diurnal variation of air currents in a valley. Figure 19a shows the sunrise with the onset of upslope winds (white arrows) and the continuation of mountain drainage winds (black arrows). Figure 19b shows the forenoon transition from down mountain to up valley winds, Fig. 19c shows the early afternoon "fully developed valley wind with diminishing slope winds. Figure 19d is in the late afternoon with only a valley wind. Figure 19e is in the evening with the beginning of downslope winds and a diminishing valley wind. Figure 19f is the early night and is the transition from valley to mountain winds showing well-developed downslope winds. Figure 19g is the middle of the night with continuing downslope winds and fully developed mountain winds. Figure 19h is the late night to morning with downslope winds ceasing and full mountain winds. This sequence illustrates that a measuring site on the plains area would experience CCW rotation with time as the spectra indicate and is similar to rotation of tidal currents in an embayment. This phenomenon can produce mesoscale offshore winds in an Arctic coastal zone at least 20 km seaward where only onshore mesoscale winds were thought to exist. In effect this valley drainage wind acts as a false summer land breeze in sections of an Arctic coastline having river valley wind systems with the proper geometry. This mountain valley wind system acts to augment the onshore afternoon seabreeze in the Arctic and to reverse the flow at night to offshore under favorable synoptic conditions.

The amount of variance contained in the mesoscale frequencies in the rota ry spectal plots for the open water months again points to the inadequacies of Nome land station data to drive oil spill trajectory models in offshore areas.

6. Summary and conclusions

The use of several analytical "tools" on surface meteorological time series of pressure, temperature, wind speed and wind direction from Nome, Northeast Cape and Unalakleet has led to important results for the Norton Sound. A profound influence of mesoscale effects was discovered both of orographic and thermal causes. These effects only play a part in actual transport of pollutants or ice floes in a narrow zone within 20 km of the coastline. However, they mask the "real" wind direction in the Sound proper which is often different from the wind directions and speeds recorded at coastal sites. The extent of this difference is ample evidence that Nome and Unalakleet winds should not be used as input for oil spill trajectory models unless in the very nearshore.

Combined mesoscale effects in the Sound's warmest open water months averaged 33% for Unalakleet and 26% for Nome. In the coldest ice covered months, mesoscale effects (mainly orographic) averaged 25% at both Nome and Unalakleet. The approximate summer large scale wind field as determined by pressure data from the above three stations indicates a general westerly flow which coupled with the sea breeze effect would bring out-of-Sound pollutants toward the Yukon Delta.

Rotary spectral analysis has pinpointed a summer wind system due to river valleys running perpendicular to coastlines and cutting through mountain ranges at Nome and Unalakleet. This mountain valley system produces winds that augment shoreward blowing sea breezes in the afternoons, but create "false" offshore blowing land breezes in the evening. The Arctic coastal areas were thought to be void of land breezes since the land stayed warmer than the water in the summer (Kozo, 1982).

This study has quantified the amount of mesoscale influence in the Sound with further breakdowns into orographic and thermal causes. The necessary preliminary determination of the large scale wind field gives a good approximation of the winds that would affect the Yukon Delta. The percentage of thermally induced mesoscale effects seen in the summer Yukon Delta region will be similar to the Sound proper. Future studies in the Delta should no longer concentrate on the frequency of sea breeze occurrence but on the offshore extent instead. This offshore extent may be greater than 20 km for several reasons. The convex shape of the coastline can act to focus the onshore winds creating a convergence and uplift over land. This will tend to increase the “drawing” power of the onshore winds. The land elevations are low in the delta area which precludes mountain valley systems and other orographic effects that might cause opposing offshore flows. The land surface itself with a large extent of mud flats may heat up faster and to a greater extent than areas with more common tundra grass type surfaces.

7. Acknowledgement

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APPENDIX A

BIVARIATE DISTRIBUTIONS FOR NOME AND UNALAKLEET

S P E E D (ms^{-1}) (ohs. 248)

DIRECTION

	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	29-22	22-24	24-26	26-28	28-30	TOTAL	PER
326.0-349.5	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	5	2.0
303.5-326.0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0. 0
281.0-303.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
250.5 -201.0	1	2	2	1	0	0	0	0	0	0	a	0	0	0	0	6	2. 0
236, 0-258. 5	0	3	4	1	0	0	0	0	0	0	0	0	0	0	0	a	3.0
213.5-236.0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.0
191.0-213.5	0	1	0	0	a	0	0	0	0	0′	0	0	0	0	0	1	0.0
166.5-191.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
146. 0-168.5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0. 0
123.5-146.0	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	7	2.0
101,0-123.5	4	13	6	3	3	1	0	0	0	0	0	0	0	0	0	30	12. 0
78.5-101.0	4	16	26	25	41	37	9	0	0	0	0	0	0	0	0	158	63.0
56.0- 78.5	2	2	3	1	0	0	0	0	0	0	0	0	0	0	0	a	3.0
33.5- 56. 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
11.0- 33.5	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0.0
348.5- 11,0	19	1	0	0	0	0	0	0	0	0	0	0	0	0	0	20	8. 0

Table AU-I. Bivariate distribution of wind direction versus wind speed data (three hourly) for Unalakleet, in January, 1964. Winds above 14 ins-l are considered gale class.

SPEED (ins-l) (ohs. 248)

DIRECTION	0- 2	2-4	4-"6	6-0	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	TOTAL	PER
326. 0-340.5	1	3	Q	0	0	0	0	0	0	u	0	0	0	0	0	4	1.0
303.5-326,0	1	3	1	Q	0	0	0	0	0	0	0	0	0	0	0	S	2.0
281. ?-203. s	1	1	1	2	2	0	0	0	0	Q	0	0	0	0	0	7	2.0
250.5-201.0	0	2	3	1	0	0	0	0	0	0	Q	0	0	0	0	6	2.0
236. 0-258. 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	a	0. 0
213,5 -236.0	0	1	0	0	a	0	0	0	0	0	0	0	0	0	0	1	Q. 0
191. 0-213.5	0	1	0	0	Q	0	0	0	0	Q	0	0	0	0	0	1	et!
1HI.5-191,0	0	Q	e	0	0	0	0	0	0	0	0	Q	0	0	0	0	0. Q
146. 0-168. 5	0	1	0	0	u	0	0	0	0	a	Q	0	0	0	0	1	0.0
1?3.5-146.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0. 0
191.9-123.5	1	3	1	0	0	Q	Q	0	0	0	0	0	Q	0	0	5	2.0
78.5-101.0	1	4	13	17	11	14	7	3	0	0	0	Q	0	0	0	70	28.0
56.0- 70.5	0	8	7	8	4	2	2	2	0	0	0	Q	0	0	Q	33	13.0
33.5- 56.0	0	4	1	4	3	3	4	0	0	0	0	0	0	0	0	19	7.0
11.0- 33.5	0	9	5	7	4	2	Q	0	0	0	0	Q	0	0	0	27	10.0
348.5- 11.0	46	11	7	4	1	0	0	0	0	0	0	0	0	0	0	69	27.0

Table AN-1. **Bivariate distribution of wind direction versus wind speed data (three hourly) for Nome, in January, 1964. Winda above 14 ms^{-1} are considered gale class.**

SPEED (ms⁻¹) (Ohs. 248)

DIRECTION (Vg)	0.0	11.0	33.5	56.0	78.5	101.0	123. S	146.0	160.5	191.0	213s5	236.0	258.5	281.0	303.5	326.0	TOTAL	PER
326.0-348.5	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	4	1.0
303.5-326.0	5	1	0	2	5	0	2	0	0	0	a	0	1	0	0	0	16	6.9
281.0-303,5	1	0	0	1	25	9	3	1	0	0	0	1	3	0	0	0	44	17.0
258.5-281,0	3	0	0	0	28	10	0	0	0	0	0	4	1	0	1	0	47	18.0
236.0-258.5	0	0	0	1	7	4	0	0	0	0	1	0	0	0	0	0	13	5.0
213.5-236,0	1	0	0	1	10	3	0	0	0	0	0	0	0	0	0	0	15	6.0
191.0-213,5	2	0	0	0	6	0	1	0	0	0	0	1	0	0	0	0	10	400
168.5-191.0	1	0	0	0	18	1	0	0	0	0	0	0	0	0	0	0	20	8.0
146.0-168.5	0	0	0	0	31	1	0	0	0	1	0	1	1	0	0	0	35	14.0
123.5-146.0	2	0	0	3	23	2	0	0	0	0	0	1	0	0	0	0	31	12.0
101.0-123.5	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	4	1.0
78.5-101.0	4	0	0	0	0	0	0	a	0	0	0	0	0	0	0	1	5	2*0
56,0- 78.5	0	0	l?	0	0	0	0	0	0	0	0	0	0	0	a	1	1	0. a
33.5- 56,0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0.0
11.0- 33,5	0	B	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0.0
348.5- 11.0	0	1	0	0	Q	0	0	0	0	0	0	0	0	0	0	0	1	0.0

Table AU-2. Bivariate distribution of calculated geostrophic winds (Vg) versus Unalakleet simultaneous surface winds (Us) for January, 1964. Horizontal directions represent the same sectors as the vertical except that 0 is the middle of the 348.5°-11.0° sector instead of the minimum direction value.

DIRECTION (Vg)	DIRECTION (US')																	(ohs. 248)
	0.@	11.0	33.-5	56.0	78.5	101.0	123.5	146.0	1.68.5	191.0	213.5	236	.0258,5	281.0	303.5	326,	TOTAL	PER
326. C-348,5	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	4	1.0
303,5-326.0	8	6	0	a	1	0	0	0	0	0	0	0	0	1	0	0	16	6.0
281.0-303,5	16	11	2	1	1	1	0	1	0	0	0	0	3	2	3	3	44	17.0
258. 5-281.0	21	5	5	3	4	1	0	0	0	1	1	0	0	4	1	1	47	18.0
236.0 -258,5	3	2	2	0	4	0	0	0	0	0	0	0	2	0	0	0	13	5.0
213,5-236,0	3	0	6	3	2	0	0	0	0	0	0	0	0	0	1	0	15	6, 0
191, 0-213.5	1	0	1	1	6	0	0	0	0	0	0	0	1	0	0	0	10	4*0
168.5-191.0	1	0	1	6	12	0	0	0	0	0	0	0	0	0	0	0	20	8. 0
146.0 -168.5	1	1	2	10	19	2	0	0	0	0	e	0	0	0	0	0	35	14.0
123,5- 146.0	3	1	0	6	20	1	0	0	0	0	a	0	0	0	0	0	31	12,9
101.0-123.5	0	1	0	2	1	0	0	0	0	0	0	0	0	0	0	0	4	1.0
78.5-101. 0	5	0	a	a	0	0	0	0	0	0	0	a	0	0	0	0	5	2.0
56.0- 78.5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.0
33.5- 56.0	1	0	0	0	0	El	0	0	0	0	0	0	0	0	0	0	1	0. 0
11.:- 33.5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.0
348.5- 11.0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0. 0

Table AN-2. Bivariate distribution of calculated geoatrophic winda (Vg) versus Nome simultaneous surface winda (Ns) for January, 1964. Horizontal directions represent the same sectors as the vertical except that O is the middle of the 348.5°-11.00 sector instead of the minimum direction value.

S P E E D (ins-l) (ohs. 248)

DIRECTION	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	TOTAL	PER
325, C-348.5	"1	11	15	3	0	0	0	0	0	0	0	0	0	0	0	30	12. 0
303.5-326.0	3	10	9	2	1	0	0	0	0	0	0	0	0	0	0	25	10.0
281.0-303.5	2	12	3	2	0	0	0	0	0	0	0	0	0	0	0	19	7.0
258.5-201. 0	9	14	11	3	0	0	0	0	0	0	0	0	0	0	0	37	14. a
236.0-258.5	2	9	9	0	0	0	0	0	0	0	0	0	0	0	0	20	8.0
213. 5-236. 0	2	5	7	0	0	0	0	0	0	0	0	0	0	0	0	14	5.0
191. 0-?13.5	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0.0
168.5-191.0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0. 0
146.0-168.:	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.0
123.5-146.0	5	4	2	1	0	0	0	0	0	0	0	0	0	0	0	12	4.0
101.0-123.5	7	12	3	0	0	0	0	a	0	0	0	0	0	0	0	22	8. 0
70.5 -101.0	5	12	7	1	0	0	0	0	0	0	0	0	0	0	0	25	10. 0
56.0- 78.5	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	3	1.0
32.5- 56.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	008
11,0- 33.5	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1.0
340.5-11. 'a	24	5	i?	3	0	0	0	a	0	0	0	0	0	0	0	34	13. 0

Table AU-3 Bivariate distribution of wind direction versus wind apeed data (three hourly) for Unalakleet, in July, 1964. Winds above 14 ms^{-1} are considered gale class,

	S P E E D (ms-1)														(ohs. 248)	
R E C T I o N	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-26	28-30	TOTAL	PER
326.0-340.5	2	3	4	3	0	0	0	0	0	0	0	0	0	0	0	12	4.5
303.5-326.0	3	6	1	3	0	0	0	0	0	0	0	0	0	0	0	13	5.0
201.0-303.5	0	5	5	2	0	0	0	0	0	0	0	0	0	0	0	12	4.0
258.5-281.0	0	7	11	7	3	4	0	0	0	0	0	0	0	0	0	32	12.0
236.0-258.5	2	5	10	5	1	0	0	0	a	0	0	0	a	0	0	23	g*;
213.5-236.0	1	10	9	0	0	0	0	0	0	0	0	0	0	0	0	20	6.3
191.0-213.5	0	3	6	0	0	0	0	0	0	0	0	0	a	0	0	9	3.3
168.5-191.0	4	20	10	1	0	0	0	0	0	0	0	0	0	0	0	35	14.2
146.0-168.5	0	3	5	0	0	0	0	0	0	0	0	0	0	0	0	8	3.0
123.5-146.0	1	2	3	1	0	0	0	0	0	0	0	0	0	0	0	7	2.8
: 101.0-123.5	0	0	2	3	0	1	0	0	0	0	0	0	0	0	0	6	2.0
78.5-101.0	0	1	7	2	4	1	0	0	0	0	0	0	0	0	0	11	4.0
56.0-70.5	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	3	1.3
33.:-.56.0	1	2	2	5	1	0	0	0	0	0	0	0	0	0	0	11	4.0
11.0-32.5	1	1	a	4	0	0	0	0	0	0	0	0	a	0	0	6	2.0
348.5-11.0	22	5	6	4	2	1	0	0	0	0	0	0	0	0	0	40	16.0

Table AN-3. Bivariate distribution of wind direction versus wind speed data (three hourly) for Nome, in July, 1964. Winds above 14 ms^{-1} are considered gale class.

D I R E C T I O N (Us) (obs. 248)

D I R E C T I O N (Vg)	0.0	11.0	33.5	56.0	78.5	101.0	123.5	146.0	168.5	191.0	213.5	236.0	258.5	281.0	303.5	326.0	TOTAL	PER
326.0-348.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0.0
303.5-326.0	5	0	0	0	0	1	0	0	0	0	1	0	0	0	1	5	13	5.0
281.0-303.5	12	2	0	1	1	3	1	0	1	0	8	3	7	4	10	12	65	26.0
258.5-281.0	2	0	0	0	5	2	2	0	0	0	2	8	16	8	3	1	49	19.0
236.0-258.5	3	0	0		3	9	4	1	0	[illegible]	[illegible]	5	3	2	5	2	39	5.0
213.5-236.0	4	1	0	0	6	4	2	0	0	1	0	1	6	1	2	3	31	12.0
91.0-2 3.5	5	[illegible]	0	[illegible]	2	[illegible]	[illegible]	0	0	0	2	3	[illegible]			2	2[illegible]	9.0
168.5-191.0	2	0	0	1	5	0	1	0	0	0	1	0	1	2	2	0	15	6.0
146.0-168.5	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	2	4	1.0
123.5-146.0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	3	1.0
101.0-123.5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	3	1.0
78.5-101.0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.0
56.0- 78.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
33.5- 56.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0.0
11.0- 33.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
348.5- 11.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0

Table AU-4. Bivariate distribution of calculated geostrophic winds (Vg) versus Unalakleet simultaneous surface winds (Us) for July, 1964. Horizontal directions represent the same sectors as the vertical except that 0 is the middle of the 348.5°-11.0° sector instead of the minimum direction value

DIR EC TION (Us) (obs. 248)

DIRECTION (Vg)	0.0	11.0	33.5	56.0	70.5	101.0	123.5	146.0	166.5	191.0	213.5	236.9	258.5	261.0	303.5	326.0	TOTAL	PER
326.0-348.5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0.0
303.5-326.0	6	0	0	0	0	a	0	0	0	0	0	1	2	1	0	3	13	5.0
281.0-303.5	14	5	6	1	1	1	0	1	6	2	1	6	8	3	5	5	65	26.0
258.5-201.0	d	0	0	0	0	1	0	1	5	0	5	6	13	4	5	1	49	19.0
236,0-250.5	7	1	0	0	1	0	1	0	3	3	4	6	7	2	2	2	39	15.0
213.5-236.0	3	0	3	0	3	2	2	2	5	2	6	1	0	1	1	a	31	12.0
191.0-213.5	1	0	0	1	3	1	1	3	9	0	2	0	2	0	0	a	23	9.0
168.5-191.0	0	0	2	0	3	1	2	0	4	1	1	1	0	0	0	0	15	5.0
146.0-1613.5	0	0	0	0	0	0	1	1	2	0	0	0	0	0	0	a	4	1.0
123.5-146.0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	3	1.0
101.0-123.5	1	9	0	0	0	0	0	0	1	1	0	0	0	0	0	0	3	1.0
78.5-1% 1.0	0	0	0	0	0	0	0	0	0	a	0	1	0	a	0	a	1	0.0
56.0- 70.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
33.5- 56.0	0	0	0	0	0	0	0	0	0	0	1	0	0	a	0	0	1	0.0
11.0- 32,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
348.5- 11.0	0	0	0	a	0	0	0	0	0	0	0	0	a	0	0	a	0	0.0

Table AN-4. Bivariate distribution of calculated geostrophic winds (Vg) versus Nome simultaneous surface winds (Ns) for July, 1964. Horizontal directions represent the same sectors as the vertical except that O is the middle of the 348.5°-11.00 sector instead of the minimum direction value.

S P E E D (ins-l) (ohs. 248)

DIRECTION	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	TOTAL	PER
326. 0-348.5	1	0	i	0	0	0	0	0	0	0	0	0	0	0	0	2	0.0
303. 5-326*0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	4	1.0
281. 5-333.5	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	3	1.0
258. 5-281. 0	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	6	2.0
236. 0-258. 5	1	a	2	0	0	0	0	0	0	0	0	0	0	0	0	3	1.0
213. 5-2X.0	0	2	4	1	0	0	0	0	0	0	0	0	0	0	0	7	2. 0
191.0-213.5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	a. 0
166.5-191,8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.%
146. 0-168.5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	a. 0
123.5- 146,0	3	0	2	0	0	0	0	0	0	0	0	0	0	0	0	5	2* 0
101.0-123.5	6	7	6	4	3	3	3	0	0	0	0	0	0	0	0	32	12.9
78.5-101.0	8	12	12	21	33	34	11	6	0	0	0	0	0	0	0	137	55.0
56. a- 7e. 5	2	12	2	0	1	0	0	0	0	0	0	0	0	0	0	17	6.8
33. 5- 56.0	2	4	2	0	0	0	0	0	0	0	0	0	0	0	0	8	3.0
11. 0- 33. 5	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	3	1.0
346,5-:1.0	e	7	3	0	0	0	0	0	0	0	0	0	0	0	0	18	7.3

Table AU-5. Bivariate distribution of wind direction versus wind speed data (three hourly) for Unalakleet, in January, 1965. Winds above 14 ins-l are considered gale class.

SPEED (ins-l) (ohs. 248)

DIRECTION	0-2	2-4	4-6	6-0	8-10	10-12	:2-14	14-16	16-18	18-20	20-22	22-24	24-26	26-20	20-30	TOTAL	PER
326. 0-342.5	6	7	3	3	1	0	1	0	0	0	0	0	0	0	0	21	8.0
303,5-325.0	2	3	2	2	0	1	0	0	0	0	1	0	0	0	0	11	4.0
201,0-383.5	0	3	3	2	1	0	0	0	0	0	0	0	0	0	0	9	3.0
258. 5-281. 0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0.0
236. 0-258. 5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.3
213.5-236. 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
191.0-2:3.5	0	*,	e	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
168.5- 191.0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0.0
146. 0-168.5	0	a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
122.5- 146.0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	3	1.0
101.0-123.5	1	4	1	1	3	2	0	1	0	0	0	0	0	0	0	13	5.0
78.5-101. 0	3	6	9	7	8	14	4	4	2	0	0	0	0	0	0	57	22.0
56.0- 70.5	3	7	3	2	4	5	1	2	0	0	0	0	0	0	0	27	10.0
33.5- 56. 0	2	2	4	6	8	4	1	1	2	0	0	0	0	0	0	30	12.0
1:.0- 33.5	1	6	3	3	4	3	0	0	0	0	0	0	0	0	0	20	8.0
346.5- 11. 0	16	2a	4	10	3	0	0	0	0	0	0	0	0	0	0	53	21.0

Table AN-5. Bivariate distribution of wind direction versus wind speed data (three hourly) for Nome, in January, 1965. Winds above 14 ins-i are considered gale class.

DIRECTION (Vg)	0.0	11.0	33.5	56.0	78.5	101.0	123.5	146.0	168.5	191.0	213.5	236.0	258.5	281.0	303.5	326.0	TOTAL	PER
326.0-348.5	2	0	3	2	3	1	0	0		0	1	0	0	0	0	0	[illegible]	5.0
303.5-326.0	9	3	2	4	7	8		0	0	1	3	2	3	1		2	47	8.[illegible]
281.0-303.5	6	0	0	1	16	4	0	0	0	0	2	0	1	0	2	0	32	12.0
258.5-281.0	1	0	0	0	12	2	0	0	0	0	0	0	0	0	0	0	15	6.0
236.0-258.5	0	0	0	0	6	3	0	0	0	0	0	0	0	0	0	0	9	3.0
213.5-236.0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	2	[illegible].0
191.0-213.5	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	4	1.0
168.5-191.0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	4	1.0
146.0-168.5	0	0	0	0	5	1	1	0	0	0	0	0	0	0	0	0	7	2.0
123.5-146.0	0	0	0	0	24	2	0	0	0	0	0	0	0	0	0	0	26	10.0
101.0-123.5	0	0	0	0	22	0	0	0	0	0	0	0	1	1	0	0	24	9.0
78.5-101.0	0	0	0	0	10	0	0	0	0	0	0	1	1	1	1	0	14	5.0
56.0- 78.5	0	0	1	0	8	1	0	0	0	0	1	0	0	0	0	0	11	4.0
33.5- 56.0	0	0	0	2	9	3	0	1	0	0	0	0	0	0	0	0	15	6.0
11.0- 33.5	0	0	2	4	3	2	3	0	0	0	0	0	0	0	0	0	14	5.0
348.5- 11.0	0	0	0	4	5	2	0	0	0	0	0	0	0	0	0	0	11	4.0

Table AU-6. Bivariate distribution of calculated geostrophic winds (Vg) versus Unalakleet simultaneous surface winds (Us) for January, 1965. Horizontal directions represent the same sectors as the vertical except that 0 is the middle of the 348.5°-11.0° sector instead of the minimum direction value.

DIRECTION (Us) (obs. 248)

DIRECTION (Vg)	0.0	11.0	33.5	56.0	78.5	101.0	123.5	146.0	168.5	191.0	213.5	236.0	258.5	281.0	303.5	326.0	TOTAL	PER
326.0-348.5	3	1	2	1	0	1	0	0	0	0	0	0	0	1	1	3	13	5.0
303.5-326.0	23	2	2	1	3	1	0	0	0	0	0	0	1	6	2	6	47	18.0
281.0-303.5	10	4	0	2	1	2	0	0	0	0	0	0	0	2	5	6	32	12.0
258.5-281.0	1	1	4	4	3	1	1	0	0	0	0	0	0	0	0	0	15	6.0
236.0-258.5	1	1	3	1	3	0	0	0	0	0	0	0	0	0	0	0	9	3.0
213.5-236.0	0		0	0		1		0	0	0	0	0	0	0	0	0	2	0.0
191.0-213.5	0	1	≤	1	2	0	0	0	0	0	0	0	0	0	0	0	4	1.0
168.5-191.0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	4	1.0
146.0-168.5	0	1	0	1	4	1	0	0	0	0	0	0	0	0	0	0	7	2.0
123.5-146.0	0	0	0	1	22	2	1	0	0	0	0	0	0	0	0	0	26	10.0
101.0-123.5	1	0	2	6	11	2	0	0	1	0	0	1	0	0	0	0	24	9.0
78.5-101.0	4	1	3	0	3	0	1	0	0	0	0	0	0	0	1	1	14	5.0
56.0- 78.5	1	1	3	4	0	0	0	0	0	0	0	0	1	0	0	1	11	4.0
33.5- 56.0	4	2	5	3	1	0	0	0	0	0	0	0	0	0	0	0	15	6.0
11.0- 33.5	2	2	3	1	1	0	0	0	0	0	0	0	0	0	2	3	14	5.0
348.5- 11.0	3	3	3	1	0	0	0	0	0	0	0	0	0	0	0	1	11	4.0

Table AN-6. Bivariate distribution of calculated geostrophic winds (Vg) versus Nome simultaneous surface winds (Ns) for January, 1965. Horizontal directions represent the same sectors as the vertical except that 0 is the middle of the 348.5°-11.0° sector instead of the minimum direction value.

SPEED (ins-l) (ohs. 248)

DIRECTION

	0-2	2-4	4-6	E-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-26	20-30	TOTAL	PER
326. 2-39,5	0	5	4	1	0	0	0	0	0	0	0	0	0	0	0	10	4.0
302. 5-326,0	0	6	14	0	1	1	0	0	0	0	0	9	0	0	9	22	8.0
281. 0-303. 5	1	12	9	1	1	0	0	0	0	0	0	0	0	9	0	24	9.0
258. 5-281. 0	4	15	14	2	1	3	0	0	0	0	0	0	9	0	0	39	15.9
226,0-250.5	4	6	3	10	5	2	0	0	0	0	8	0	0	0	0	30	1209
213. 5-?36,0	1	8	8	4	3	0	0	0	0	0	0	9	0	0	9	24	9.0
191. 0-213.5	2	4	5	3	0	0	0	0	0	e	0	9	0	9	0	14	5.0
168.5- 191.0	1	4	2	3	0	0	0	0	0	0	9	9	0	0	9	19	4.0
146.0-168.5	2	5	4	3	0	0	0	0	0	0	0	0	0	0	0	14	5.0
123.5-146.0	4	5	S	0	0	0	1	0	0	0	0	0	0	0	0	15	6.0
101. 0-123.5	0	7	6	?	0	0	0	0	0	0	9	0	0	0	0	15	6.0
78.5-101.0	0	5	10	4	1	0	0	0	0	0	0	0	0	0	0	211	8.0
56. 0- 76.5	1	0	1	3	0	0	0	0	0	0	0	0	0	0	9	5	2.0
33.5- 56.0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.0
11.0-33,5	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0.0
349.5- 11.0	4	1	0	0	0	0	0	0	0	a	0	0	0	0	0	5	2.0

Table AU-7. Bivariate distribution of wind direction versus wind speed data (three hourly) for Unalakleet, in July, 1965. Winds above 14 ins-i are considered gale class.

SPEED (m s^{-1}) (obs. 248)

DIRECTION

DIRECTION	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	TOTAL	PER
326.0-348.5	1	4	1	0	0	0	0	0	0	0	0	0	0	0	0	6	2.0
303.5-326.0	0	5	1	4	0	2	0	1	0	0	0	0	0	0	0	13	5.0
281.0-303.5	2	2	3	4	0	0	0	0	0	0	0	0	0	0	0	11	4.0
258.5-281.0	0	6	7	11	11	4	0	0	0	0	0	0	0	0	0	39	15.0
236.0-258.5	1	6	12	10	1	4	0	0	0	0	0	0	0	0	0	34	13.0
213.5-236.0	0	5	7	2	0	0	0	0	0	0	0	0	0	0	0	14	5.a
191.0-213.5	0	2	6	4	0	0	0	0	0	0	0	0	0	0	0	12	4.3
168.5-191.0	3	8	8	11	3	0	0	0	0	2	0	0	0	0	0	33	13.0
146.0-168.5	1	4	2	2	4	0	0	0	0	0	0	0	0	0	0	13	5.0
123.5-146.0	0	0	8	8	2	5	0	1	0	0	0	0	0	0	0	24	9.0
101.0-123.5	0	1	2	6	3	1	2	1	0	0	0	0	0	0	0	16	6.0
78.5-101.0	0	1	2	5	0	0	0	0	0	0	a	0	0	0	0	a	"Iii
56.0- 78.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
33.5- 56.0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0.0
11.0- 33.5	0	0	0	0	0	0	0	0	0	0	3	0	0	3	3	3	0.0
348.5- 11.0	19	3	0	1	1	0	0	0	0	0	0	0	0	0	0	24	9.0

Table AN-7. **Bivariate distribution of wind direction versus wind speed data (three hourly) for Nome, in July, 1965. Winds above 14 m s^{-1} are considered gale class.**

D I R E C T I O N (Us) (obs. 248)

D I R E C T I O N (Vg)	0.0	11.0	33.5	56.0	78.5	101.0	123.5	146.0	168.5	191.0	213.5	236.0	258.5	281.0	303.5	326.0	TOTAL	PER
326.0-348.5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	2	0.0
303.5-326.0	0	0	0	0	0	1	2	0	0	0	1	1	2	1	1	1	10	4.0
281.0-303.5	1	0	0	0	0	0	1	0	1	5	5	2	7	4	5	3	34	13.0
258.5-281.0	2	0	0	0	0	2	2	0	2	1	7	7	11	7	7	3	51	20.0
236.0-258.5	0	0	0	0	2	2	2	4	0	2	4	4	5	1	4	≤	3≤	2.0
213.5-236.0	0	0	0	0	4	0	1	0	0	2	1	11	3	4	0	1	27	10.0
191.0-213.5	0	0	0	0	5	1	2	3	0	0	1	2	3	3	1	1	22	8.0
168.5-191.0	0	0	0	0	2	4	0	3	4	1	2	1	3	3	0	0	23	9.0
146.0-168.5	0	0	0	0	3	3	3	2	2	2	2	2	0	0	0	1	20	8.0
123.5-146.0	0	0	0	3	4	0	1	2	1	0	1	0	2	0	1	0	15	6.0
101.0-123.5	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	3	1.0
78.5-101.0	1	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	6	2.0
56.0- 78.5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.0
33.5- 56.0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0.0
11.0- 33.5	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0.0
348.5- 11.0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0.0

Table AU-8. Bivariate distribution of calculated geostrophic winds (Vg) versus Unalakleet simultaneous surface winds (Us) for July, 1965. Horizontal directions represent the same sectors as the vertical except that 0 is the middle of the 348.5°-11.0° sector instead of the minimum direction value.

DIR EC TION (Us) (ohs. 248)

DIRECTION (Vg)	0.0	11.0	33.5	56.0	78.5	101.0	123.5	146.0	168.5	191.0	213.5	236,0	258.5	281.0	303.5	326.0	TOTAL	PER
326.0-348.5	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0.0
383.5 -325.0	0	0	0	0	0	0	0	0	0	0	0	2	2	1	4	1	10	4.0
281.0-303.5	3	0	0	0	0	0	0	0	0	1	0	6	13	5	4	2	34	13.0
258.5-281.0	8	0	0	0	1	0	0	1	2	0	1	13	19	2	3	1	51	20.0
236.0-250,5	2	0	0	0	0	3	0	1	7	4	6	3	2	0	1	1	30	12.0
213.5-236.0	1	0	0	0	1	1	2	2	9	5	2	3	1	0	0	0	27	10.0
191.0-213.5	2	0	0	0	2	1	6	1	3	1	2	2	1	0	1	0	22	8.0
168,5-191.0	0	0	0	a	2	5	5	3	4	0	1	2	0	1	0	0	23	9.0
146.0-168.5	0	0	1	0	0	4	8	2	2	1	2	0	0	0	0	0	20	8.Q
123.5-146.0	2	0	0	0	2	1	3	1	5	0	0	0	1	0	0	0	15	6.0
101.0-123.5	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	3	1.0
78.5-101.0	2	0	0	0	0	0	0	2	0	0	0	1	0	0	0	1	6	2.0
56.0- 78.5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	Q	0	1	0.0
33.5- 56.0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.0
11.0- 33.5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	a	1	0.0
348.5- 11.0	2	0	0	a	0	0	0	0	0	0	0	0	0	0	0	0	2	[illegible] a

Table AN-8. Bivariate distribution of calculated geostrophic winds (Vg) versus Nome simultaneous surface winda (Ns) for July, 1965. Horizontal directions represent the same sectors as the vertical except that 0 ia the middle of the 348,5°-11.00 sector instead of the minimum direction value.

S P E E D (ms-1) (ohs. 248)

DIRECTION

	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	TOTAL	PER
326.9-348.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	a	0	0.0
303.5-326,0	0	0	0	0	0	0	0	0	0	0	Q	0	0	0	0	0	0.0
201,0-393.5	0	0	a	0	0	0	a	0	0	0	0	0	0	0	0	a	9.0
258.5-281.0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	9	9	0.0
236.9-258.5	0	0	0	0	0	a	0	0	0	a	0	9	9	0	0	0	0.0
213.5-236,0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0*0
191.9-213.5	a	0	0	0	0	0	0	0	0	0	0	9	0	0	0	a	0.0
168.5-191.0	0	0	0	0	0	0	0	0	0	9	Q	0	9	0	9	0	0.0
146.9-168.5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.0
123.5-146.0	0	0	0	0	0	Q	0	0	0	0	0	0	0	9	0	0	0.0
101.0-123.5	0	1	u	1	1	0	0	0	0	0	0	0	0	0	0	3	1.0
78.5-101.0	1	5	5	13	35	74	62	12	3	4	0	0	0	0	0	214	86.0
56.0-78.5	0	1	3	4	8	11	1	1	0	9	9	0	0	0	9	29	11.9
33.5-56.0	0	0	0	0	u	0	0	0	0	0	9	0	0	0	0	0	0.0
11.0-33.5	0	0	0	0	0	1	0	0	0	0	9	0	0	0	9	1	0.0
348.5-11.0	0	0	0	u	0	0	0	0	0	0	0	0	9	0	9	0	il.0

Table AU-9. Bivariate distribution of wind direction versus wind speed data (three hourly) for Unalakleet, in January, 1966. Winds above 14 ins-l are considered gale class.

SPEED (ins-l) (ohs. 248)

DIRECTION

	0-2	2-4	4-6	6-0	0-10	10-12	12-14	14-16	16-18	10-20	28-22	22-24	24-26	26-28	20-20	TOTAL	PER
326. 0-348. 5	k?	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	e. a
303.5-326. 0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	3	1.0
201. 0-303. 5	1	3	0	0	0	0	0	0	0	0	0	0	0	9	0	4	1.0
258.5-26 :.0	1	0	a	0	0	0	0	0	0	0	0	0	0	0	0	1	a. a
236.9-258.5	1	0	0	0	0	0	0	0	0	0	9	9	0	9	0	1	0.0
213.5-236.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	a	a. a
191. 0-213. 5	0	0	0	0	0	0	a	0	0	a	0	a	0	a	0	a	0.0
168.5-191.0	1	3	0	0	0	0	0	0	0	0	0	0	0	a	0	4	L 9
146. 0-168. 5	0	2	0	0	0	0	0	0	0	a	0	0	0	0	0	2	0. 0
123.5-146. 0	0	0	1	0	0	0	0	0	0	0	0	0	a	0	0	1	0. 0
101. %122.5	0	2	0	0	0	0	a	0	0	a	0	9	a	9	0	2	0.0
78.5-101.0	0	7	7	6	10	13	5	21	1	0	9	0	a	0	0	70	28, 0
55a- 78.5	2	12	6	4	5	8	16	a	0	0	0	9	9	0	0	53	21.0
33.5-'55. 0	0	2	4	5	4	3	3	1	0	0	9	0	0	0	0	22	a. 0
11.9- 32.5	1	1	3	5	2	3	5	0	0	a	9	0	0	a	0	2a	0. a
348.5- 11.0	54	3	3	2	1	0	1	a	0	0	0	9	0	a	0	64	2s. a

Table AN-9. Bivariate distribution of wind direction versus wind speed data (three hourly] for Nome, in January, 1966. Winds above 14 ins-l are considered gale class.

DIRECTION (Us) (obs. 248)

DIRECTION (Vg)

	0.0	11.0	33.5	56.0	78.3	101.0	123.5	146.0	168.5	191.0	213.5	236.0	258.5	281.0	303.5	326.0	TOTAL	PER
326.0-348.5	0	0	0	1	5	0	0	0	0	0	0	0	0	0	0	0	6	2.0
303.5-326.0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0.0
281.0-303.5	0	0	0	1	2	1	0	0	0	0	0	0	0	0	0	0	4	1.0
258.5-281.0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	5	2.0
236.0-258.5	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	2	0.0
213.5-236.0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3	1.0
191.0-213.5	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3	1.0
168.5-191.0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	4	1.0
146.0-168.5	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	19	7.0
123.5-146.0	0	0	0	6	59	0	0	1	0	0	0	0	0	0	0	0	66	26.0
101.0-123.5	0	1	0	9	72	2	0	0	0	0	0	0	0	0	0	0	84	33.0
78.5-101.0	0	0	0	4	27	0	0	0	0	0	0	0	0	0	0	0	31	12.0
56.0-78.5	0	0	0	3	4	0	0	0	0	0	0	0	0	0	0	0	7	2.0
33.5-56.0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3	1.0
11.0-33.5	0	0	0	2	4	0	0	0	0	0	0	0	0	0	0	0	6	2.0
348.5-11.0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	3	1.0

Table AU-10. Bivariate distribution of calculated geostrophic winds (Vg) versus Unalakleet simultaneous surface winda (Us) for January, 1966. Horizontal directions represent the same sectors as the vertical except that 0 is the middle of the 348.5°-11.0° sector instead of the minimum direction value.

D I R E C T I O N (Us) (obs. 248)

D I R E C T I O N (Vg)	0.0	11.0	33.5	56.0	78.5	101.0	123.5	146.0	168.5	191.0	213.5	236.0	258.5	281.0	303.5	326.0	TOTAL	PER
326.0-348.5	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	6	2.0
303.5-326.0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	2	0.0
281.0-303.5	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	4	1.0
258.5-281.0	1	0	1	2	1	0	0	0	0	0	0	0	0	0	0	0	5	2.0
236.0-258.5	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0.0
213.5-236.0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	3	1.0
191.0-213.5	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	3	1.0
168.5-191.0	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	4	1.0
146.0-168.5	2	1	1	5	7	1	1	1	0	0	0	0	0	0	0	0	19	7.0
123.5-146.0	8	5	4	10	36	1	0	0	2	0	0	0	0	0	0	0	66	26.0
101.0-123.5	24	6	11	21	19	0	0	0	1	0	0	1	0	1	0	0	84	33.0
78.5-101.0	10	3	3	5	5	0	0	0	1	0	0	0	1	2	1	0	31	12.0
56.0- 78.5	3	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	7	2.0
33.5- 56.0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3	1.0
11.0- 33.5	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	2.0
348.5- 11.0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	3	1.0

Table AN-10. Bivariate distribution of calculated geostrophic winds (Vg) versus Nome simultaneous surface winds (Ns) for January, 1966. Horizontal directions represent the same sectors as the vertical except that 0 is the middle of the 348.5°-11.0° sector instead of the minimum direction value.

SPEED (ins-l) (ohs. 248)

DIRECTION

	6-2	2- 4	4- 6	6- 8	0-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	TOTAL	PER
326.0-342.5	0	2	6	2	1	0	0	0	0	0	0	0	0	0	0	11	4. 0
302. 5-326. 0	2	3	6	3	1	0	0	Q	0	0	0	0	0	e	0	15	6.9
201.0-203. s	0	6	5	2	0	0	0	0	0	0	0	0	0	0	0	13	5. 0
258. 5-281. 0	0	12	6	0	0	0	0	0	0	0	0	0	0	0	0	10	7. a
236. 0-258. 5	0	12	10	3	8	0	0	0	0	0	0	0	0	0	0	33	13. a
213. 5-236.0	0	4	8	1	4	4	0	0	0	0	0	0	0	0	0	21	8. 0
191.0-2 13.5	1	2	1	0	5	2	0	9	0	0	0	0	0	0	0	11	4.0
166.5-191.0	1	3	5	4	1	0	0	0	0	0	0	0	0	0	0	14	5. 0
146.0-168.5	0	3	4	1	2	0	0	0	0	0	0	0	0	0	0	10	4.$
123. 5-146.0	0	7	7	4	0	0	0	0	0	0	0	0	0	0	0	18	7.0
101.0-122.5	1	6	14	3	2	0	0	0	0	0	0	0	0	0	0	26	10. 0
78.5-101.0	0	6	17	10	6	i	0	0	a	0	0	0	0	0	0	40	16.0
56.0- 7.3.5	0	4	4	3	2	0	0	0	0	0	0	0	0	0	0	13	5.0
33.5- 56.3	1	0	0	0	0	0	0	0	a	0	0	0	0	0	0	1	0.0
11. 0- 33.5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.0
340.5- 11.0	1	1	1	0	0	0	0	0	0	0	0	0	a	a	0	3	1.0

Table AU-11. Bivariate distribution of wind direction versus wind speed data (three hourly) for Unalakleet, in July, 1966. Winds above 14 ❑ s,-i are considered gale class.

SPEED (ins-l) (ohs. 248)

DIRECTION

	0-2	2-4	4-6	6-a	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	TOTAL	PER
326.0-348.5	0	1	0	0	0	0	0	0	0	0	a	0	0	0	0	1	0.0
303.5-326.0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	6	2*0
281.0-383.5	1	7	1	2	0	0	0	0	0	0	0	0	0	0	0	11	4*0
258.3-201.0	2	9	8	4	1	0	0	0	0	0	0	0	0	0	0	24	9.0
236.9-250.5	1	5	17	3	3	0	0	0	0	0	0	0	0	0	0	29	11.0
213.5-236.0	1	11	6	1	0	0	0	0	0	0	0	0	0	0	0	19	7* a
19:.21-213.5	1	5	5	1	0	3	1	0	0	0	0	0	0	0	0	16	6.$)
168.5-191.0	2	11	3	2	3	3	1	0	0	0	0	0	0	0	0	25	10.0
146,3-16! .5	2	4	9	3	0	0	0	0	0	0	0	0	0	0	0	18	7.0
123,5-146, e	0	5	9	7	2	0	0	0	0	0	0	0	0	0	0	23	9.0
101.0-123.5	0	7	4	6	8	2	0	0	a	0	0	0	0	0	0	27	10.0
78.5-101.0	1	1	6	5	1	0	0	0	0	0	0	0	0	0	0	14	5.2
56.0-78.5	0	1	3	1	1	0	0	0	0	0	0	0	0	0	0	6	2.0
33.5-56.0	0	4	0	2	0	0	0	0	0	0	0	0	0	0	0	6	2.0
11.0-33.s	1	3	i?	3	0	0	0	0	0	0	0	0	0	0	0	9	3.0
348.5-11.0	5	5	0	2	2	0	0	0	0	0	0	0	0	0	0	14	5.0

Table AN- Il. Bivariate distribution of wind direction versus wind speed data (three hourly) for Nome, in July, 1966. Winds above 14 ins-l are considered gale class.

DIR EC TION (Us) (ohs. 248)

DIRECTION (Vg)	0.0	11.0	33,5	56,0	78.3	101.0	122.5	146.0	168.5	191.0	213.5	226.9	258.5	201.0	203.5	326.0	TOTAL	PER
326.0-348.5	0	0	0	1	1	a	0	0	a	0	0	0	0	0	1	2	5	2.0
303.5-326.0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	3	1.0
281.0-303.5	0	0	0	1	1	1	0	0	a	0	0	1	0	0	1	0	5	2.0
258.5-281.0	0	0	0	0	1	1	0	0	3	0	3	2	2	2	3	2	19	7.0
236.0-258.5	0	0	0	1	5	7	2	1	2	5	7	8	2	4	1	0	45	18.0
213.5-236.0	1	0	0	1	3	2	0	1	1	1	5	5	1	2	0	0	23	9.0
191.0-213.5	1	0	1	0	5	s	3	4	4	4	1	3	2	1	1	0	35	14.0
168.5-191.0	0	0	0	3	3	1	8	2	2	0	2	2	3	0	1	0	27	10.0
146.0-168.5	0	0	0	0	4	3	4	2	1	1	2	4	4	2	2	0	29	11.0
123.5-146.0	0	a	0	1	9	2	0	0	0	0	0	5	1	2	0	?	22	8.0
101.0-123.5	0	1	0	4	4	2	1	0	0	0	1	1	2	0	4	2	22	8.0
78.5-101.0	1	a	0	1	1	1	0	0	0	0	0	0	1	0	0	?	7	2.0
56.0- 78.5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	a	1	0.0
33.5- 56.0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	3	1.0
11.0- 33.5	0	a	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0.0
348.5- 11.0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0.0

Table AU-12. Bivariate distribution of calculated geostrophic winds (Vg) versus Unalakleet simultaneous surface winds (Us) for July, 1966. Horizontal directions represent the same sectors as the vertical except that 0 is the middle of the 348.5°-11.00 sector instead of the minimum direction value.

DIRECTION (Us) (obs. 248)

DIRECTION (Vg)	0.0	11.0	33.5	56.0	78.5	101.0	123.5	146.0	168.5	191.0	213.5	236.0	258.5	281.0	303.5	326.0	TOTAL	PER
326.0-348.5	1	1	0	0	0	0	0	0	2	0	0	1	0	0	0	0	5	2.0
303.5-325.0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	1.0
281.0-303.5	2	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	5	2.0
258.5-281.0	1	1	0	0	0	2	1	0	2	0	2	5	3	2	0	0	19	7.0
236.0-258.5	3	0	0	1	1	3	1	1	4	2	5	8	12	4	0	0	45	18.0
213.5-236.0	0	1	0	0	2	1	0	2	3	3	3	4	3	1	0	0	23	9.0
191.0-213.5	3	2	0	1	2	5	2	2	8	4	1	1	2	0	2	0	35	14.0
168.5-191.0	0	0	0	2	1	5	9	4	2	2	1	1	0	0	0	0	27	10.0
146.0-168.5	0	0	0	0	2	5	4	5	2	2	3	3	1	2	0	0	29	11.0
123.5-146.0	1	0	1	0	5	4	2	3	1	1	2	2	0	0	0	0	22	8.0
101.0-123.5	0	4	2	2	0	2	4	1	0	2	1	1	0	0	2	1	22	8.0
78.5-101.0	0	0	3	0	1	0	0	0	1	0	0	0	1	0	1	0	7	2.0
56.0- 78.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0.0
33.5- 56.0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	3	1.0
11.0- 33.5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.0
348.5- 11.0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0.0

Table AN-12. Bivariate distribution of calculated geostrophic winds (Vg) versus Nome simultaneous surface winds (Ns) for July, 1966. Horizontal directions represent the same sectors as the vertical except that ° is the middle of the 348.5°-11.0° sector instead of the minimum direction value

SPEED (ms^{-1}) (obs. 248)

DIRECTION	0- 2	2- 4	4- 6	6- 8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	TOTAL	PER
326.0-348.5	0	1	6	1	0	0	0	0	0	0	0	0	0	0	0	8	3.0
303.5-326.0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0.0
281.0-303.5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.0
258.5-281.0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	4	1.0
236.0-258.5	1	1	3	5	1	2	0	0	0	0	0	0	0	0	0	13	5.0
213.5-236.0	0	0	4	2	5	3	1	1	0	0	0	0	0	0	0	16	6.0
191.0-213.5	0	0	0	3	0	1	0	0	0	0	0	0	0	0	0	4	1.0
168.5-191.0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	3	1.0
146.0-168.5	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	3	1.0
123.5-146.0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	3	1.0
101.0-123.5	1	10	8	10	6	0	2	0	0	0	0	0	0	0	0	37	14.0
78.5-101.0	1	6	15	18	29	31	21	3	4	4	4	0	0	0	0	136	54.0
56.0- 78.5	0	0	3	0	1	1	0	0	0	0	0	0	0	0	0	5	2.0
33.5- 56.0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	3	1.0
11.0- 33.5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.0
348.5- 11.0	1	2	4	2	0	0	0	0	0	0	0	0	0	0	0	9	3.0

Table AU-13. Bivariate distribution of wind direction versus wind speed data (three hourly) for Unalakleet, in January, 1967. Winds above 14 ms^{-1} are considered gale class.

S P E E D (ins-l-) (obs. 248)

DIRECTION

	0- 2	2- 4	4-6	6-8	8-10	113-12	:2-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	TOTAL	PER
3?6.0-348.5	0	2	5	1	2	a	a	a	a	0	0	0	a	0	a	la	4.0
303.5-326.0	1	2	2	1	1	1	0	a	0	0	0	0	0	0	0	8	3. a
201.0-303.5	2	1	3	1	a	a	a	a	0	a	0	a	0	0	a	7	2. 0
258.5-261.0	0	4	2	3	0	a	a	a	0	0	0	a	0	0	0	9	3. 0
236. 0-258.5	1	1	1	0	a	a	a	a	a	0	0	a	a	0	a	3	1.0
213.5-236.0	1	0	0	1	1	0	0	a	0	Q	0	a	a	0	0	3	1. 0
191.8-213.5	0	0	2	1	5	a	a	a	a	0	a	a	a	0	0	8	3. a
168.5-191.0	0	0	1	3	a	1	a	a	0	0	a	a	a	0	0	5	2.0
146.9- 168.5	0	0	2	2	3	2	0	a	0	a	0	a	a	0	0	9	3.0
122.5-146.0	0	1	2	1	1	a	a	a	0	0	0	a	0	0	0	5	2.0
101.0-123.5	2	4	4	1	3	a	a	a	a	0	a	a	a	0	a	14	5. 0
70.5-101.0	0	7	10	15	6	6	10	1	2	1	0	1	1	a	0	60	24.0
56.0- 78.5	1	2	12	9	4	2	0	0	0	0	0	a	0	0	0	30	12.0
33.5-56. 0	0	3	5	4	2	4	0	0	0	a	0	a	a	0	a	18	7*9
11.2-33.5	0	7	2	0	1	2	2	a	0	0	0	a	0	0	0	14	5. a
348.5- 11,0	35	7	2	0	0	1	0	0	0	0	0	a	a	0	0	45	18.0

Table AN-13. **Bivariate distribution of wind direction versus wind apeed data (three hourly) for Nome, in January, 1967. Winds above 14 ms^{-1} are considered gale class.**

DIRECTION (Us) (ohs. 248)

DIRECTION (Vg)	0.0	11.0	33.5	56.0	78,5	101,0	123,5	146.0	168.5	191.0	213.5	236.0	256.5	281.6	303.5	326.	TOTAL	PER
326.0-348.5	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	3	1.0
303.5-326.0	3	0	0	0	3	1	0	0	0	1	0	0	0	0	1	4	13	5.0
281.0-303.5	1	0	0	0	3	1	0	0	0	2	2	0	1	0	0	2	12	4*0
258.5-281.9	0	0	0	0	3	2	0	0	0	0	5	3	0	1	0	0	14	5.0
236.0-258.5	0	0	0	0	3	4	1	0	0	0	1	2	0	0	0	0	11	4.0
213.5-236.0	0	0	0	0	5	2	0	0	1	0	0	1	0	0	0	0	9	' 3.0
191.0-213.5	0	0	0	0	4	3	1	0	0	0	3	1	0	0	0	Q	12	4.0
168.5-191.0	0	0	1	0	12	3	1	0	1	0	2	0	0	0	0	0	20	8.0
146.0-168.5	1	0	1	0	16	0	0	0	1	1	1	0	0	0	0	0	21	8.0
123.5-146.0	0	0	0	1	40	4	0	3	0	0	2	4	1	0	0	0	55	22.0
101.0-123.5	0	0	0	0	23	3	0	0	0	0	0	1	1	0	0	Q	28	11.0
78.5-101.0	1	0	1	3	11	5	0	0	0	'a	0	0	i	0	0	1	23	9.0
56.0-78.5	2	0	0	1	4	4	0	0	0	0	0	0	0	0	1	9	12	4.@
33.5-56.0	0	0	0	0	4	1	0	0	0	0	0	0	0	0	0	0	5	2.0
11.0-33.5	0	0	0	0	3	2	0	0	0	0	0	0	0	0	0	1	6	2.0
340.5-11.0	1	1	0	Q	1	1	0	0	0	0	0	0	0	0	0	0	4	1.0

Table AU-14. Bivariate distribution of calculated geostrophic winds (Vg) versus Unalakleet simultaneous surface winds (Us) for January, 1967. Horizontal directions represent the same sectors as the vertical except that O is the middle of the 348.5°-11.00 sector instead of the minimum direction value.

DIR EC TION (US) (ohs . 248)

DIRECTION (Vg)

	0. 0	11.0	33.5	56.0	70.5	101. 0	123.5	146.8	168. 5	191.0	213.5	236.0	250.5	281. 0	303.5	326. 0	TOTAL	PER
326. 0-348. 5	0	a	0	0	0	0	0	0	0	0	1	0	2	0	0	0	3	L 0
3113.5-326.0	6	2	0	1	0	0	13	0	0	0	0	0	0	2	1	1	13	5. 0
281.0-303,5	4	2	0	0	0	0	0	0	0	0	0	0	0	0	2	4	12	4*0
258. 5-281.0	4	1	0	0	0	0	a	0	0	0	0	0	2	2	1	4	14	5* 0
236.0-250.5	3	0	0	1	0	0	0	0	0	0	2	2	2	0	1	0	11	4.0
213. 5-236. 0	3	0	0	0	2	0	0	0	0	2	0	0	1	1	0	0	9	3.0
191.0-213.5	1	0	0	0	1	3	0	1	3	2	0	1	0	0	0	0	12	4*0
168.5-191.0	1	0	0	2	5	0	2	6	0	3	0	0	0	0	1	0	20	8.0
146.0-168.5	0	0	1	4	12	2	1	0	0	1	0	0	0	0	0	0	21	8.0
123.5 -146.9	3	a	3	6	30	7	2	2	2	0	0	0	0	0	0	0	55	22. e
101.0- 123.5	3	0	2	14	7	2	0	0	0	0	0	0	0	0	0	0	20	11.0
78.5-101.0	5	4	7	2	2	0	0	0	0	0	0	0	0	1	1	1	23	9.0
56.0- 78.5	6	1	1	0	1	0	0	0	0	0	0	0	2	0	1	0	12	4. a
33.3- 56.9	1	3	1	0	0	0	0	0	0	0	0	0	0	0	0	a	5	2. 0
11.0- 33.5	3	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	6	2.0
348.5- 11.0	2	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	4	1.0

Table AN-14. Bivariate distribution of calculated geostrophic winds (Vg) veraus Nome simultaneous surface winds (Ns) for January, 1967. Horizontal directions represent the same sectors as the vertical except that O is the middle of the 348.5″-11.0° sector instead of the minimum direction value.

S P E E D ms^{-1}) (obs. 248)

DIRECTION	0- 2	2- 4	4- 6	6- 8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	TOTAL	PER
326.0-348.5	0	1	3	3	0	0	0	0	0	0	0	0	0	0	0	7	2.0
303.5-326.0	0	4	7	2	0	0	0	0	0	0	0	0	0	0	0	13	5.0
281.0-303.5	1	5	6	1	0	0	0	0	0	0	0	0	0	0	0	13	5.0
258.5-281.0	0	8	22	10	2	8	1	1	0	0	0	0	0	0	0	52	20.0
236.0-258.5	1	6	16	12	7	8	2	0	0	0	0	0	0	0	0	52	20.0
213.5-236.0	1	4	4	10	14	0	1	0	0	0	0	0	0	0	0	34	13.0
191.0-213.5	0	2	2	5	1	0	0	0	0	0	0	0	0	0	0	10	4.0
168.5-191.0	1	5	4	2	2	0	0	0	0	0	0	0	0	0	0	14	5.0
146.0-168.5	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	4	1.0
123.5-146.0	0	4	2	2	1	0	0	0	0	0	0	0	0	0	0	9	3.0
101.0-123.5	1	9	3	0	0	0	0	0	0	0	0	0	0	0	0	13	5.0
78.5-101.0	1	9	6	1	0	0	0	0	0	0	0	0	0	0	0	17	6.0
56.0- 78.5	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0.0
33.5- 56.0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.0
11.0- 33.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
348.5- 11.0	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	7	2.0

Table AU-15. Bivariate distribution of wind direction versus wind speed data (three hourly) for Unalakleet, in July, 1967. Winds above 14 ms^{-1} are considered gale class.

S P E E D (ms-1) (obs. 248)

D I R E C T I O N	0- 2	2-.4	4- 6	6- 8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	TOTAL	PER
326.0-348.5	2	2	3	0	0	0	0	0	0	0	0	0	0	0	0	7	2.0
303.5-326.0	2	8	0	0	0	0	0	0	0	0	0	0	0	0	0	10	4.0
281.0-303.5	1	4	2	6	0	0	0	0	0	0	0	0	0	0	0	13	5.0
258.5-281.0	1	1	15	9	2	3	0	0	0	0	0	0	0	0	0	31	12.0
236.0-258.5	0	9	15	9	1	0	0	0	0	0	0	0	0	0	0	34	13.0
213.5-236.0	1	13	17	5	0	0	0	0	0	0	0	0	0	0	0	36	14.0
191.0-213.5	0	12	14	4	1	0	0	0	0	0	0	0	0	0	0	31	12.0
168.5-191.0	0	13	8	4	0	0	0	0	0	0	0	0	0	0	0	25	10.0
146.0-168.5	1	6	5	1	1	0	0	0	0	0	0	0	0	0	0	14	5.0
123.5-146.0	0	4	5	1	0	0	0	0	0	0	0	0	0	0	0	10	4.0
101.0-123.5	1	4	1	1	0	0	0	0	0	0	0	0	0	0	0	7	2.0
78.5-101.0	0	3	2	0	0	1	0	0	0	0	0	0	0	0	0	6	2.0
56.0- 78.5	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	3	1.0
33.5- 56.0	0	3	1	1	0	0	0	0	0	0	0	0	0	0	0	5	2.0
11.0- 33.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
348.5- 11.0	10	2	3	1	0	0	0	0	0	0	0	0	0	0	0	16	6.0

Table AN- 5 Bivariate distribution of wind direction versus wind speed data (three hourly) for Nome, in July, 1967 Winds above = ms^{-1} are considered gale class

D I R E C T I O N (Us) (248 obs.)

D I R E C T I O N (Vg)

	0.0	11.0	33.5	56.0	78.5	101.0	123.5	146.0	168.5	191.0	213.5	236.0	258.5	281.0	303.5	326.0	TOTAL	PER
326.0-348.5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0.0
303.5-326.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
281.0-303.5	0	0	0	0	1	2	0	0	1	1	5	3	6	3	1	0	23	9.0
258.5-281.0	3	0	0	0	0	0	0	1	1	2	4	5	5	0	0	0	21	8.0
236.0-258.5	0	0	0	0	0	0	1	0	1	2	9	16	4	0	0	0	33	13.0
213.5-236.0	0	0	0	0	0	1	3	0	1	2	2	6	7	0	0	0	22	8.0
191.0-213.5	0	0	0	0	0	1	1	1	1	2	2	3	6	1	0	0	18	7.0
168.5-191.0	1	0	0	0	0	2	2	0	2	1	6	8	4	1	0	0	27	10.0
146.0-168.5	1	0	0	0	1	1	1	0	5	0	3	2	2	2	0	1	19	7.0
123.5-146.0	1	0	0	2	6	5	0	1	2	0	2	2	3	1	1	2	28	11.0
101.0-123.5	1	0	1	0	6	1	0	0	0	0	1	2	5	1	4	1	23	9.0
78.5-101.0	0	0	0	0	1	0	0	0	0	0	0	3	6	2	4	0	16	6.0
56.0- 78.5	0	0	0	0	0	0	0	0	0	0	0	1	3	1	2	2	9	3.0
33.5- 56.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
11.0- 33.5	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	3	1.0
348.5- 11.0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	1	1	5	2.0

Table AU-16. Bivariate distribution of calculated geostrophic winds (Vg) versus Unalakleet simultaneous surface winds (Us) for July, 1967 Horizontal directions represent the same sectors as the vertical except that 0 is the middle of the 348 5°-11 0° sector instead of the minimum direction value.

DIRECTION (US)

(ohs. 248)

DIRECTION (Vg)	0.0	11.0	33.5	56.0	78.5	101.0	123.5	146.0	168.5	191.0	213.5	236.0	258.5	281.0	303.5	326.0	TOTAL	PER
326.0-340,5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.0
303.5-326.0	a	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0.0
281.0-303.5	4	0	0	0	0	0	0	0	0	0	1	2	7	4	2	3	23	9.0
258.5-281.0	4	0	0	0	1	0	0	0	3	0	1	4	3	3	1	1	21	8.0
236.0-258,5	1	0	1	0	0	0	0	2	2	5	7	5	6	3	1	0	33	13.0
213.5-236.9	0	0	0	0	1	0	0	1	4	3	5	3	5	0	0	0	22	8.0
191.0-213.5	0	0	0	0	Q	1	2	1	1	2	8	2	1	0	0	0	18	7.0
168.5-191.0	a	a	0	0	0	1	1	2	7	10	2	2	1	1	0	0	27	10.0
146.0-168.5	0	a	0	1	2	2	0	4	2	4	1	3	0	0	0	0	19	7.0
123.5-146,0	2	0	1	0	2	2	3	3	5	2	4	1	1	0	1	1	2%	11.0
101.0-123,5	3	0	0	0	0	0	3	1	1	3	3	6	0	0	1	2	23	9.0
78.5-101.0	1	0	0	0	0	0	0	a	0	2	3	3	3	1	3	0	16	6.0
56,0-78.5	0	0	0	0	0	1	1	0	0	0	1	3	3	0	0	0	9	3.0
33*5-56.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
11.0-33.5	0	0	0	1	0	0	0	0	0	0	Q	0	1	1	0	0	3	1.0
348.5-11.0	1	0	2	1	0	0	0	0	0	0	0	0	0	0	1	0	5	2.0

Table AN-16. Bivariate distribution of calculated geostrophic winds (Vg) versus Nome simultaneous surface winds (Ns) for July, 1967. Horizontal directions represent the same sectors as the vertical except that O is the middle of the 348.5°-11.00 sector instead of the minimum direction value.

SPEED (ins-l) (ohs. 248)

DIRECTION	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	TOTAL	PER
326.0-348.5	0	3	1	4	0	e	0	0	0	0	0	0	0	0	0	8	3.0
303.5-326.0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	3	1.0
281.8 -:02.5	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	4	1.0
258. 5-201.0	0	3	0	0	3	0	0	0	0	0	0	0	0	0	0	6	2.0
236. 0-258. 5	0	2	4	1	3	"4	1	0	0	0	0	0	0	0	0	15	6.0
213.5-236. 0	1	1	2	6	5	4	2	0	0	0	0	0	0	0	0	21	8.0
191. 0-213.5	0	0	0	2	0	2	0	1	0	0	0	0	0	0	0	5	2. 0
168.5-191.0	0	0	2	0	0	1	1	0	0	0	0	0	0	0	0	4	1.0
146.0-168.5	0	1	1	2	1	1	0	0	'a	0	0	0	0	0	0	6	2.0
123,5-146,0	2	3	6	5	0	0	0	0	0	0	0	0	0	0	0	16	6.0
101. 0-123.5	1	22	17	2	3	3	1	0	0	0	0	0	0	0	0	49	19.0
78.5-101.0	2	13	12	10	13	11	1	5	2	2	0	0	0	0	0	77	31.0
5.5.0- 70.5	1	4	0	3	2	0	0	0	0	0	0	0	0	0	0	10	4.0
33,5- 56,0	2	4	1	1	0	0	0	0	0	0	0	0	0	0	0	a	3.0
11.0- 33.5	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	6	2.0
348.5-11.11	2	4	3	0	0	0	0	1	0	0	0	Q	0	0	0	10	4.0

Table AU-17. Bivariate distribution of wind direction versus wind speed data (three hourly) for Unalakleet, in January, 1968. Winds above 14 ms^{-1} are considered gale class.

SPEED (ms^{-1}) (ohs, 248)

DIRECTION

	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	TOTAL	PER
326.0-348.5	1	6	0	0	0	0	0	0	0	0	0	0	0	0	0	7	2.0.
303.5-326.0	5	4	0	e	0	0	0	0	0	0	0	0	0	e	0	9	3.0
281.0-303.5	0	6	2	0	0	0	0	0	0	0	0	0	0	0	0	8	3.0
258.5-281.0	3	3	4	0	0	0	0	0	0	0	0	0	0	0	0	10	4.0
236.0-258.5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.0
213.5-236.0	1	4	7	0	0	0	0	0	0	0	0	0	0	0	0	12	4.0
191.0-213.5	0	3	2	1	0	0	0	0	0	0	0	0	0	e	0	6	2*0
168.5-191.0	1	3	8	1	0	0	0	0	0	0	0	0	0	0	0	13	5. e
146.0-168.5	1	3	3	4	2	0	0	0	0	0	0	0	0	0	0	13	5.0
123.5-146.0	3	2	3	2	1	0	0	0	0	0	0	0	0	0	0	11	4.0
101.0-123.5	4	3	1	2	0	0	0	0	0	0	0	0	0	0	0	10	4. e
78.5-101.0	1	24	19	5	0	0	0	0	0	0	0	0	0	0	0	49	19.0
56.0- 78.5	1	13	2	1	0	0	0	0	0	0	0	0	0	0	0	17	6.0
33.5- 56.0	4	5	3	0	0	0	0	0	0	0	0	0	0	e	0	12	4.0
11.0- 33.5	4	4	1	0	0	"0	0	0	0	0	0	0	0	0	0	9	3.0
348.5- 11.0	53	6	2	0	0	0	0	0	0	0	0	0	0	e	0	61	24.0

Table AN-17. Bivariate distribution of wind direction versus wind speed data (three hourly) for Nome, in January, 1968. Winds above 14 ins-i are considered gale class.

DIRECTION (Vg)

	DIRECTION (Us)															(ohs. 248)	
	0.0	11.0	33.5	56.0	78.5	101.0	123.5	146.0	168.5	191.0	213.5	236.0	258.5	281.0	303.5	326.0	TOTAL	PER
326.0-348.5	0	1	0	0	2	8	0	0	e	0	0	0	0	0	0	1	12	4.0
30305-326,0	1	2	2	0	3	12	3	0	0	0	0	0	0	1	2	1	27	10.0
281.0-303.5	1	0	1	0	2	2	1	0	0	0	0	2	2	0	0	1	12	4.0
258.5-281.0	0	0	1	0	0	2	1	0	0	0	3	3	0	0	0	0	10	4.0
236.0-258.5	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0.0
213.5-236.0	0	0	1	0	1	2	2	0	0	2	4	1	1	0	0	0	14	5.0
191.0-212.5	0	e	0	0	3	2	e	0	[illegible]	1	1	0	0	0	0	0	8	3.0
168.5-191.0	0	0	0	0	6	1	2	1	0	0	1	2	0	0	0	0	13	5.0
! 46.0- 160.5	0	0	0	1	3	3	3	4	0	2	4	2	0	0	0	0	22	8.0
123.5-145,0	1	1	0	1	12	4	0	0	0	0	4	2	0	0	0	0	25	10.0
101.0-123.5	1	0	1	5	31	4-	0	0	3	0	1	1	2	1	0	1	51	20.0
78.5-101.0	1	0	0	0	7	3	0	0	a	0	1	1	0	0	1	0	14	5.0
56.0- 70.5	1	0	0	0	4	1	1	0	0	0	1	1	0	1	0	2	12	4.0
33, 5- 56.0	1	1	2	0	2	1	0	1	0	0	0	0	0	1	0	1	10	4.0
11,0- 33.5	2	0	0	1	1	1	2	0	0	0	0	0	1	0	0	1	9	3.0
348.5- 11.0	1	1	0	2	0	3	1	0	0	0	0	0	0	0	0	0	6	3.0

Table AU-18. Bivariate distribution of calculated geostrophic winds (Vg) versus Unalakleet simultaneous surface winds (Us) for January, 1968. Horizontal directions represent the same sectors as the vertical except that O is the middle of the 348.5°-11.00 sector instead of the minimum direction value.

DIR EC TION (Us) (ohs. 248)

DIRECTION (Vg)

	0.0	11.0	33.5	55.0	78.5	101.0	123.5	146.0	168.5	191.0	213.5	236.0	258.5	281.0	303.5	326.0	TOTAL	PER
326.0-348.5	5	0	0	0	2	1	0	0	0	0	0	0	0	1	1	2	12	4.0
303.5-326.0	a	3	5	3	1	0	1	1	0	0	0	0	0	1	2	2	27	10.0
281.0-303.5	4	0	0	0	1	1	0	0	0	0	0	0	2	1	3	0	12	4.0
258.5-281.0	1	0	0	0	1	0	0	0	0	0	0	0	5	3	0	0	10	4.0
236.0-258.5	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0.0
213.5-236.0	2	0	0	0	0	0	1	2	0	2	6	0	1	0	0	0	14	5.0
191.0-213.5	0	0	0	0	1	0	1	1	3	0	2	0	0	0	0	0	8	3.0
168.5-191.0	0	1	0	0	2	1	2	3	1	3	0	0	0	0	0	0	13	5.0
146.0-168.5	0	0	0	0	4	1	3	4	7	1	1	0	1	0	0	0	22	8.0
123.5-146.0	1	0	0	3	12	2	1	2	2	0	1	0	1	0	0	0	25	10.0
101.0-123.5	8	3	3	7	25	2	1	0	0	0	1	0	0	1	0	0	5:	22.0
78.5-101.0	13	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	5.0
56.0- 78.5	7	e	1	1	0	0	0	0	0	0	0	0	0	0	2	1	12	4.0
33.5- 56.0	[illegible]	0	2	1	0	0	0	0	0	0	0	0	0	0	0	2	10	4.0
11.0- 33.5	4	1	1	1	0	0	0	0	0	0	0	0	0	1	1	0	9	3.0
348.5- 11.0	3	0	0	1	0	2	1	0	0	0	1	0	0	0	0	0	8	3.0

Table AN-18 Bivariate distribution of calculated geostrophic winds (Vg) versus Nome simultaneous surface winds (Ns) for January, 1968. Horizontal directions represent the same sectors as the vertical except that 0 is the middle of the 348.5°-11.00 sector instead of the minimum direction value.

S P E E D (ms-1) (ohs. 248)

DIRECTION

	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-2?	22-24	24-26	26-20	28-30	TOTAL	PER
326.0-34005	0	0	1	3	1	0	0	a	a	0	0	0	0	0	0	5	2.0
34?3.5-326.0	0	2	7	6	3	1	0	0	0	0	0	0	0	e	0	19	7.0
201.0-303.5	0	6	3	2	1	0	0	0	0	0	0	0	0	0	0	12	4.0
258. 5-281.0	2	13	11	2	1	0	0	0	0	0	0	0	0	0	0	29	11.0
236. 0-258. 5	0	10	10	7	2	0	0	0	0	0	0	0	0	0	0	29	11.0
213.5-236.0	1	8	11	4	2	0	0	0	0	0	0	0	0	0	0	26	10.0
191.0-213,5	0	4	5	4	2	0	0	0	0	0	0	0	0	0	0	15	6.0
168.5-191.0	a	1	3	3	0	0	0	0	0	0	0	0	0	Q	0	7	2.0
146.0-168.5	0	3	3	2	0	0	0	0	0	0	0	0	0	0	0	8	3.@
123.5-146.0	0	3	0	1	1	0	0	0	0	0	0	0	0	0	0	S	2.0
101.0 -123.5	2	7	6	1	0	2	0	0	0	0	0	0	0	0	0	18	7.0
78.5-101.0	3	20	13	4	3	1	0	0	0	0	0	0	0	0	0	44	17.0
56.0- 78.5	1	6	4	3	0	0	0	0	0	0	0	0	0	0	0	14	5.0
33,5- 56.0	I	3	1	1	1	0	0	0	0	0	0	0	0	0	0	7	2.0
11.0- 33.5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.0
348.5- 11.0	7	2	0	0	0	0	0	0	0	0	0	0	0	0	0	9	3.0

Table AU-19. Bivariate distribution of wind direction veraus wind speed data (three hourly) for Unalakleet, in July, 1968. Winds above 14 ms^{-1} are considered gale class.

SPEED (ins-l) (ohs. 248)

DIRECTION	0-2	2-4	4-6	6-8	0-10	10-12	12-14	14-16	16-U!	18-20	20-22	22-24	24-26	26-28	28-30	TOTAL	PER
326.0-340.5	4	7	3	0	0	0	0	0	0	0	0	0	0	0	0	14	5.0
303.5-326.0	3	3	1	0	0	0	0	0	0	0	0	a	0	0	0	7	2.0
281.9-303.5	0	3	2	1	0	0	0	0	0	0	0	0	0	a	0	6	2.0
250.5-281.0	2	3	9	6	2	0	0	0	0	0	0	0	0	0	0	22	8.0
236.0-250.5	1	7	10	0	0	0	0	0	0	0	0	0	0	0	0	18	7.0
213. 5-236.0	0	4	3	0	0	0	0	0	0	0	0	0	0	0	0	7	2.0
191.0-213.5	1	6	1	0	0	0	0	0	a	0	0	0	0	0	0	8	3.0
168.5-191.0	1	11	16	8	3	0	0	0	0	0	0	0	0	0	0	39	15.0
146.0- 168.5	2	6	16	5	3	a	0	0	0	0	0	0	0	0	0	32	12.0
123.5-146.0	1	2	7	4	1	1	0	0	0	0	e	0	0	0	0	16	6.0
101.0-123.5	1	10	1	2	1	a	0	0	0	0	0	0	0	b?	0	15	6.0
78.5- 101.0	0	13	5	1	0	1	0	0	0	0	0	0	0	0	0	20	8.0
56.0- 70.5	1	0	0	3	1	Q	0	0	0	0	0	0	0	0	0	5	2.0
33.5- 56,8	0	3	2	3	0	0	0	0	0	0	0	0	0	0	0	8	3.0
11.0- 33.5	1	4	0	0	a	0	0	0	0	0	0	0	0	0	0	5	2.0
348.5- 11,0	16	8	2	0	0	0	0	0	0	0	0	0	0	0	0	26	10.0

Table AN-19. Bivariate distribution of wind direction versus wind speed data (three hourly) for Nome, in July, 1968. Winds above 14 ins-l are considered gale class.

DIR EC TION (Us) (ohs. 248)

DIRECTION (Vg)

	0.0	11.0	33,5	56.0	70.5	101.0	123.5	146.0	:60.5	191.0	213.5	236.0	25a. 5	281.0	303.5	?t6.0	TOTN-	PER
326.0-348.5	0	1	0	1	0	0	0	0	0	0	0	0	1	0	a	0	3	1.0
303.5-325.9	0	0	0	1	1	0	0	0	0	0	0	1	1	1	0	0	5	2.0
281.0-303.5	2	0	0	0	4	1	0	0	1	2	3	4	6	2	1	0	26	:0.0
258.5-281.0	1	0	0	0	3	0	0	0	0	1	8	a	1	2	1	a	25	:0.0
236.0-258.5	0	0	0	0	1	0	0	a	1	1	1	4	4	1	0	0	13	5.0
213.5-236.0	0	0	0	0	1	0	0	0	0	0	2	3	2	1	0	a	9	3.0
191.0-213.5	1	0	1	0	0	0	0	1	0	1	1	0	0	0	0	0	5	2.0
168.5-191.0	0	0	0	0	2	1	1	1	0	0	1	0	1	0	0	0	7	2.0
146,0- 168.5	1	0	2	1	4	3	1	0	1	2	2	1	1	1	0	0	20	8.0
123.5-146.0	2	0	0	6	7	8	2	4	1	2	0	2	3	0	1	0	36	15.0
101.0-123.5	2	0	4	1	7	3	0	1	2	1	1	1	2	2	9	1	37	14.0
78.5-101.0	0	0	0	2	7	2	1	1	1	2	4	3	6	2	6	2	39	15.0
56.0- 7a. 5	0	0	0	2	2	0	0	0	0	1	2	2	1	0	1	2	13	5.0
33.5- 56.0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	2	0.0
11.0- 33.5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	a	1	0.0
348.5- 11.0	0	0	0	0	4	0	0	0	0	0	1	0	0	0	0	0	5	2.0

Table AU-20. Bivariate distribution of calculated geostrophic winda (Vg) veraus Unalakleet simultaneous surface winds (Us) for July, 1968. Horizontal directions represent the same sectors as the vertical except that 0 is the middle of the 348.5°-11.0° sector instead of the minimum direction value.

DIR EC TION (Us) (ohs. 248)

n I R E C T I o. N Vg)

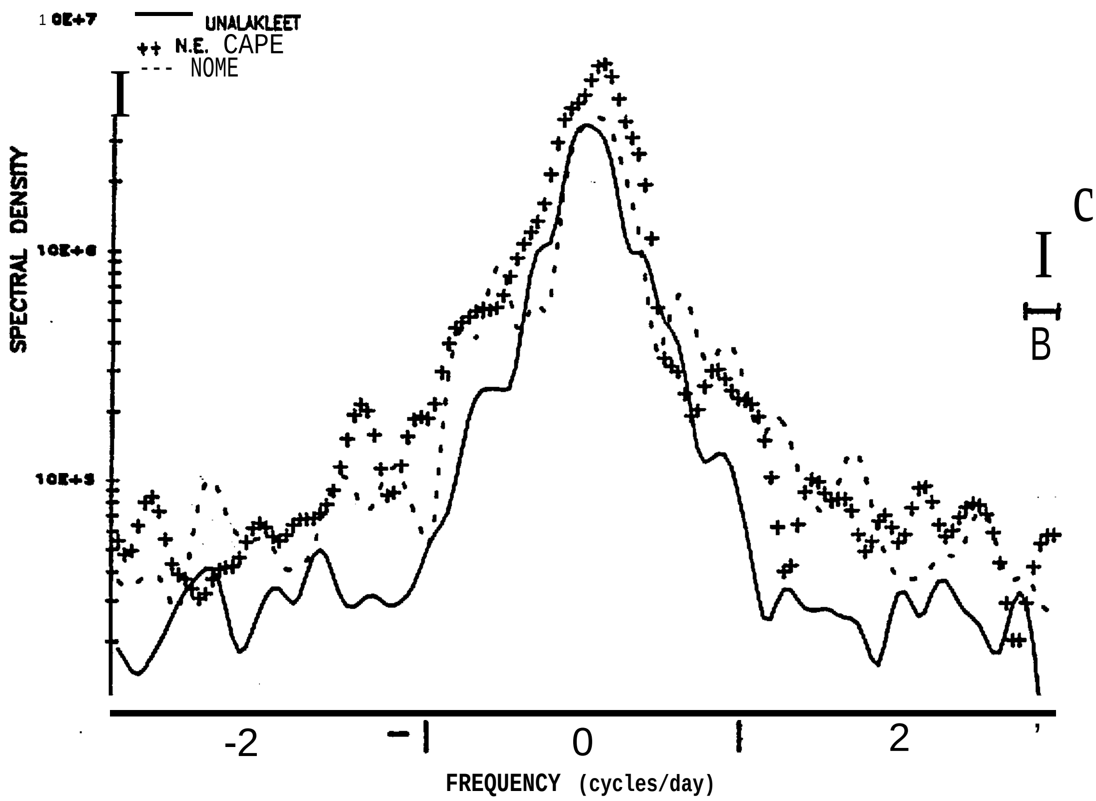
wo

	0.0	11.0	33.5	56.0	78.5	101,0	123.5	146.0	168.5	191.0	213.5	226.0	258.5	281.0	303.5	326.0	TOTAL	PER
326,0-340,5	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	3	1.0
303.5-326.0	1	0	2	1	0	0	0	0	0	0	0	0	0	0	0	1	5	2.0
281.0-303.5	6	0	2	1	1	1	0	3	1	1	0	0	5	1	1	3	26	10.0
250.5-201.0	4	0	0	0	1	0	0	0	2	2	0	5	4	0	3	4	25	10.0
236.Q-256.5	0	0	0	0	0	0	1	1	2	1	0	1	5	2	0	0	13	5.0
213.5-236.0	0	0	0	0	2	0	0	1	1	0	0	4	0	0	1	0	9	3.0
191.0-213.5	0	0	1	0	1	2	0	1	Q	0	0	0	0	0	0	0	5	2.0
168.5 -191.0	0	0	0	0	1	0	0	1	3	0	1	1	0	0	0	0	7	2.0
146* 0-168.5	1	0	0	0	4	0	2	6	4	0	2	1	0	0	0	0	20	8.0
123.5-146.0	2	0	0	1	2	3	7	12	8	1	0	0	0	2	0	0	38	15.0
101.0 -123.5	2	2	0	0	5	5	5	3	11	0	0	1	2	0	1	0	37	14.0
78.5-101.0	5	3	1	0	2	4	1	3	6	2	2	3	3	0	1	3	39	15.0
56.0- 78.5	3	0	0	0	0	0	0	1	1	1	2	1	1	0	0	3	13	5.0
33.5- 56.0	1	0	a	0	0	0	0	0	13	0	0	0	1	0	0	0	2	0.0
11* Q- 33.5	0	0	0	0	0	0	0	Q	Q	0	0	1	0	0	0	0	1	0.0
348.5- 11.0	1	0	0	2	1	0	0	0	0	0	0	0	0	1	0	0	5	2.0

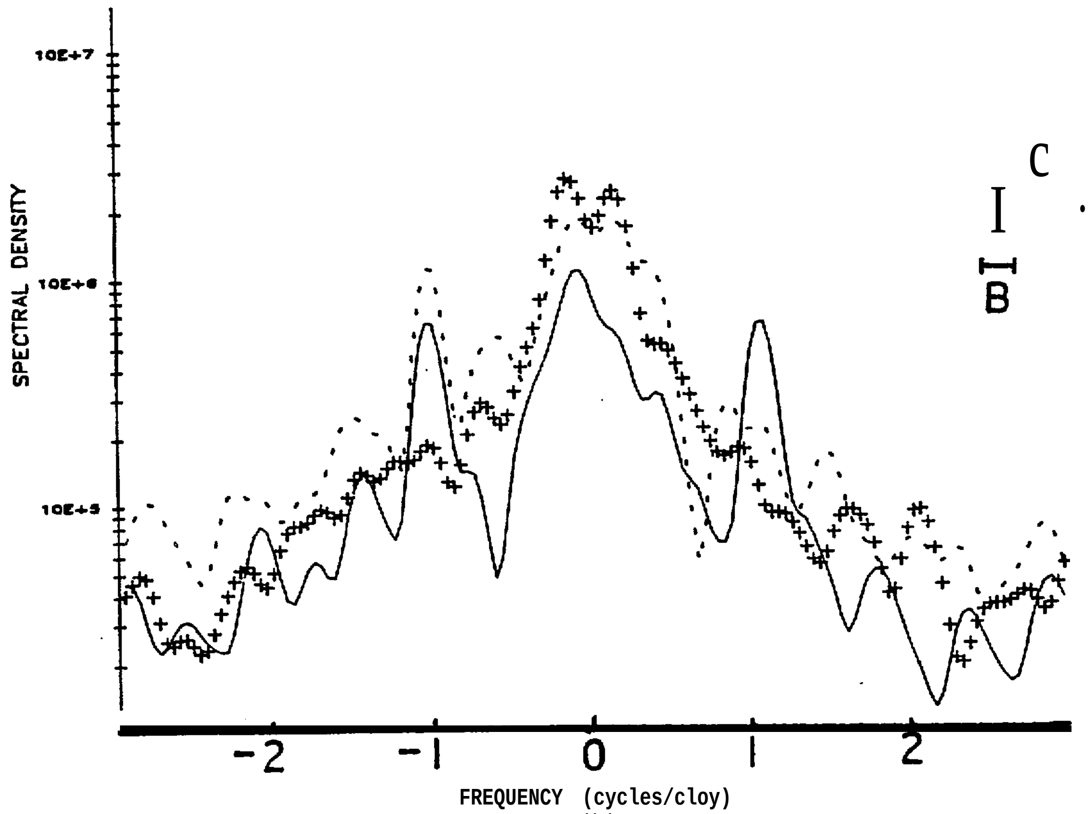
Table AN-20. **Bivariate distribution of calculated geostrophic winds (Vg) versus Nome simultaneous surface winds (Ns) for July, 1968. Horizontal directions represent the same sectors as the vertical except that 0 is the middle of the 348.5°-11.00 sector instead of the minimum direction value.**

APPENDIX B

Rotary Spectra From Northeast Cape, Unalakleet and Nome

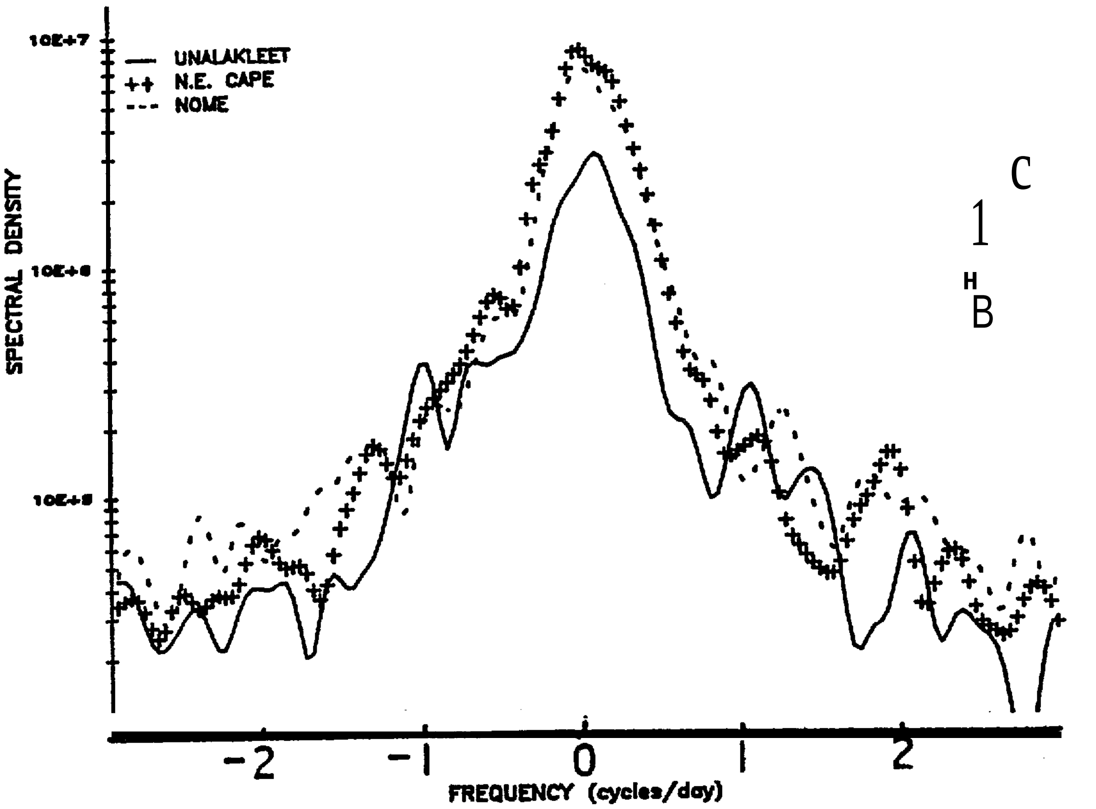


(a)

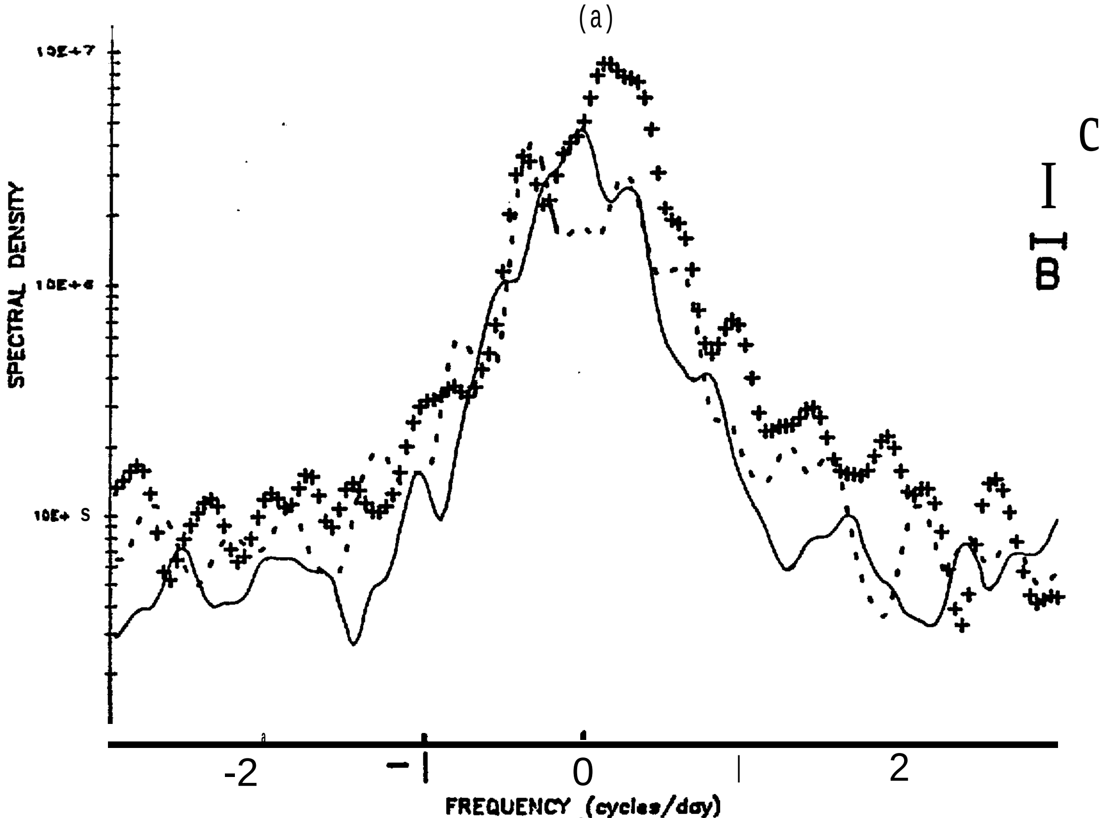


(b)

Fig. B1. Time series rotsry spectra of surface wind velocity data from Unalakleet, Northeast Cape and Nome for (a) January 1964 and (b) July 1964. The 95% confidence limits (C) and bandwidth (B) are shown.

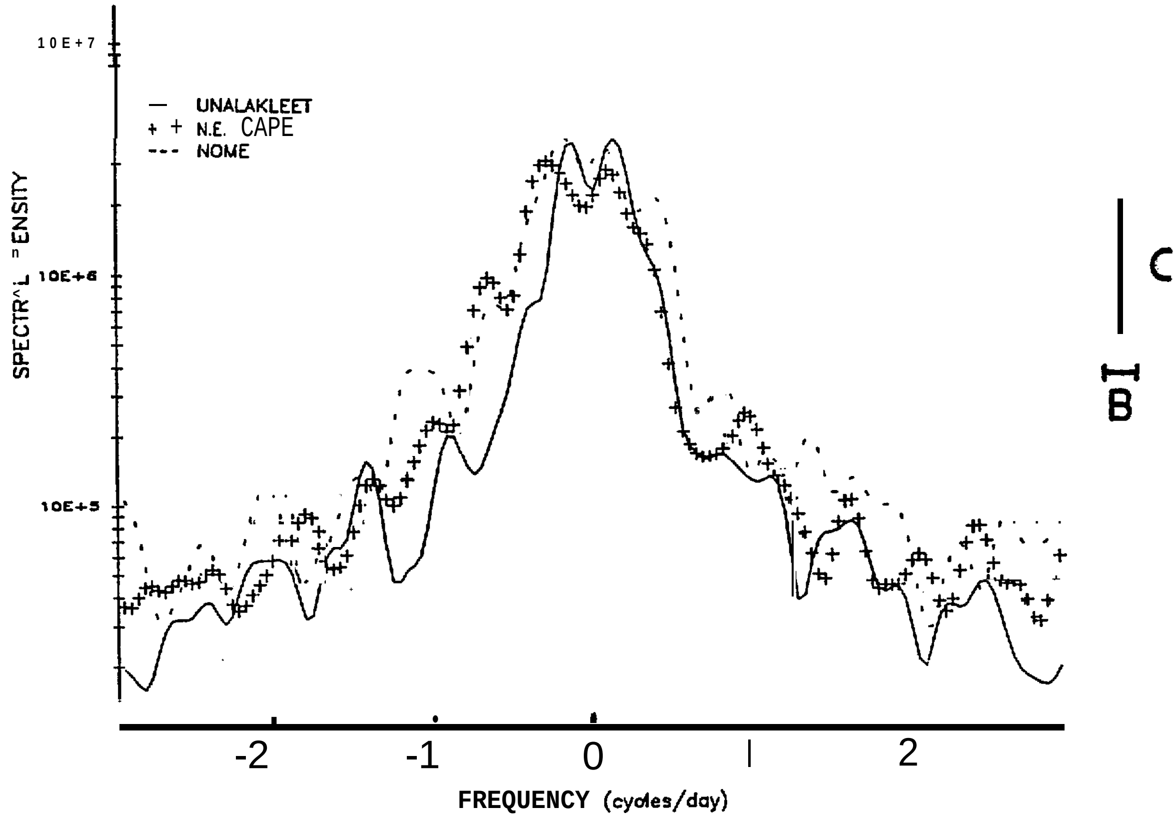


(a)

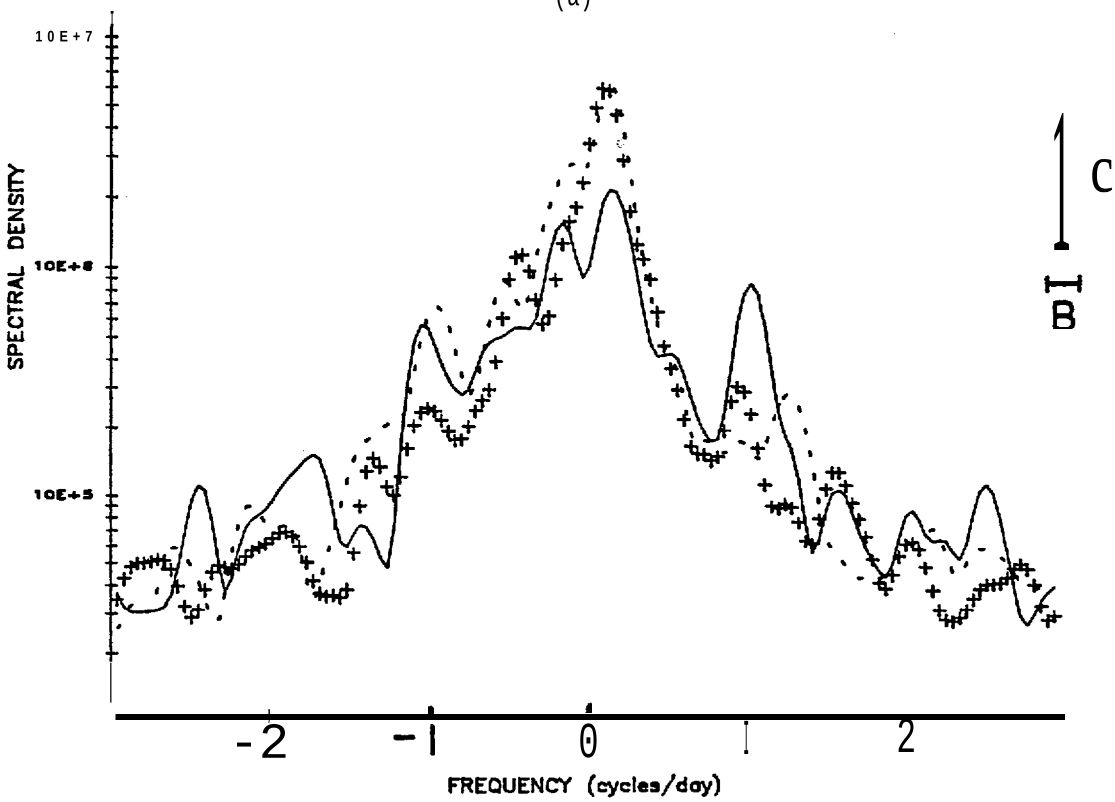


(b)

Fig. B2. Time series rotary spectra of surface wind velocity data from Unalakleet, Northeast Cape, and Nome for (a) May 1964 and (b) November 1964. The 95% confidence limits (C) and bandwidth (B) are shown.

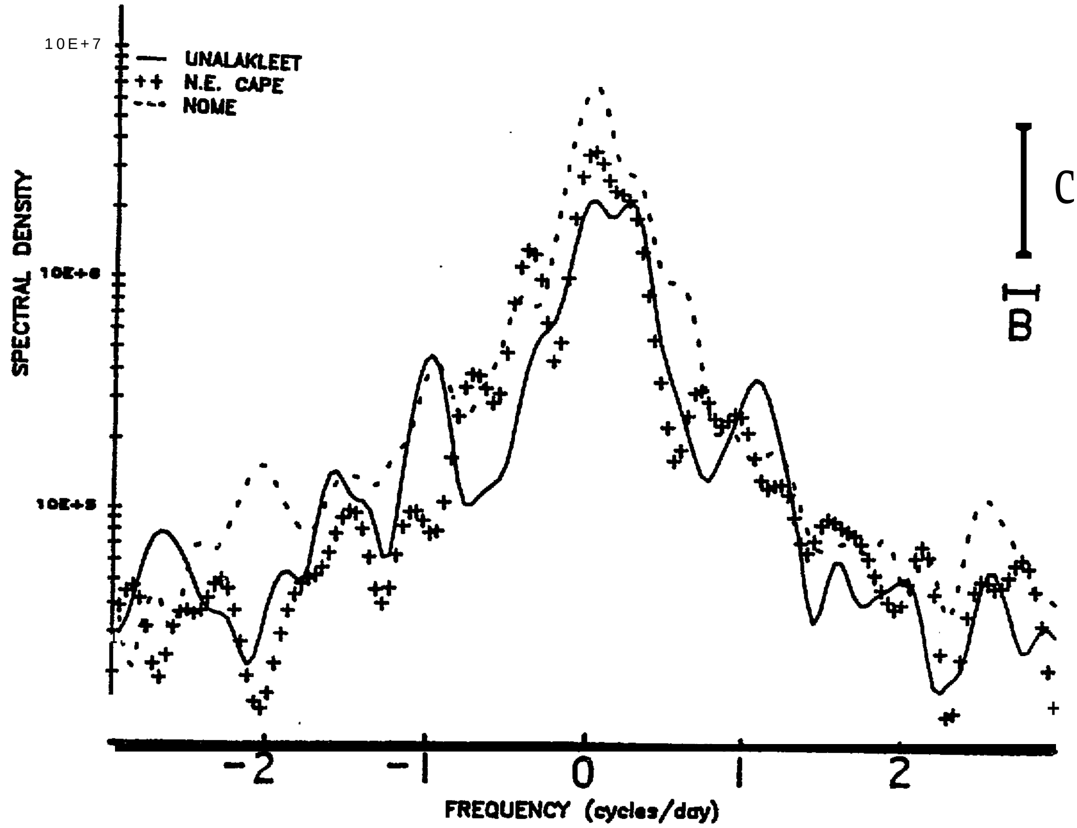


(a)

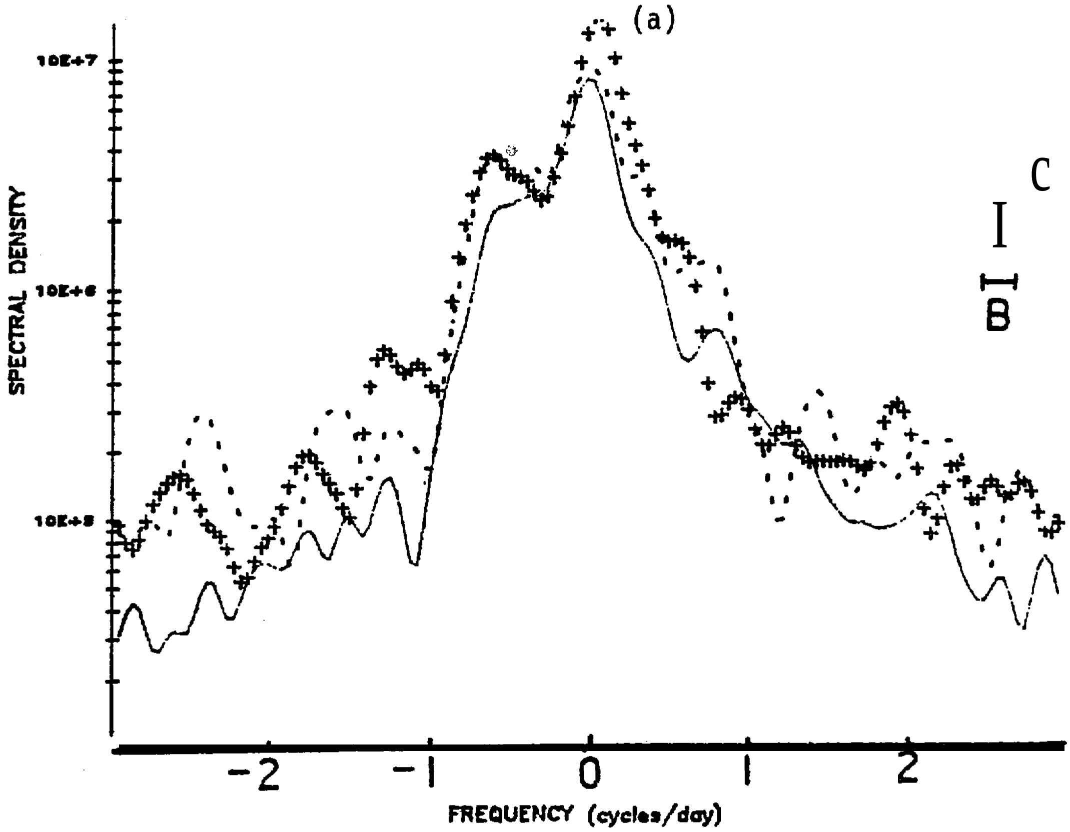


(b)

Fig. B3. Time series rotary spectra of surface wind velocity data from Unalakleet, Northeast Cape and Nome for (a) January 1965 and (b) July 1965. The 95% confidence limits (C) and bandwidth (B) are shown.

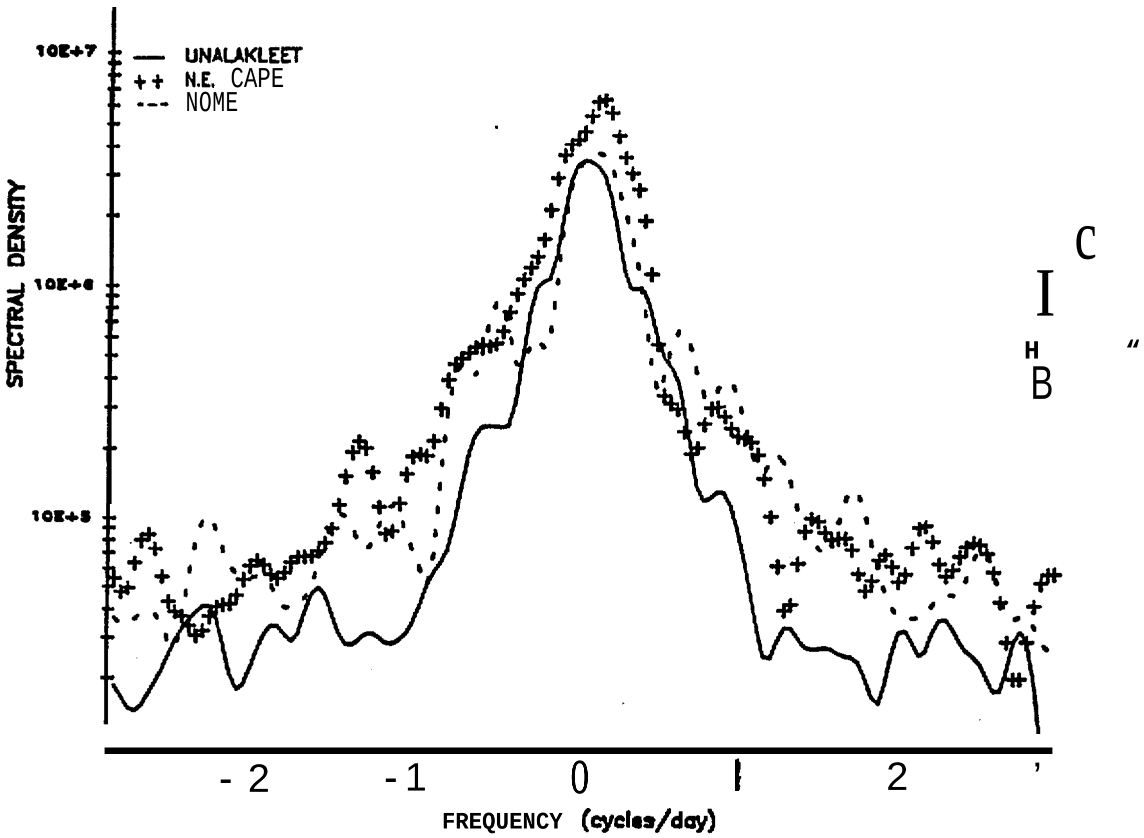


(a)

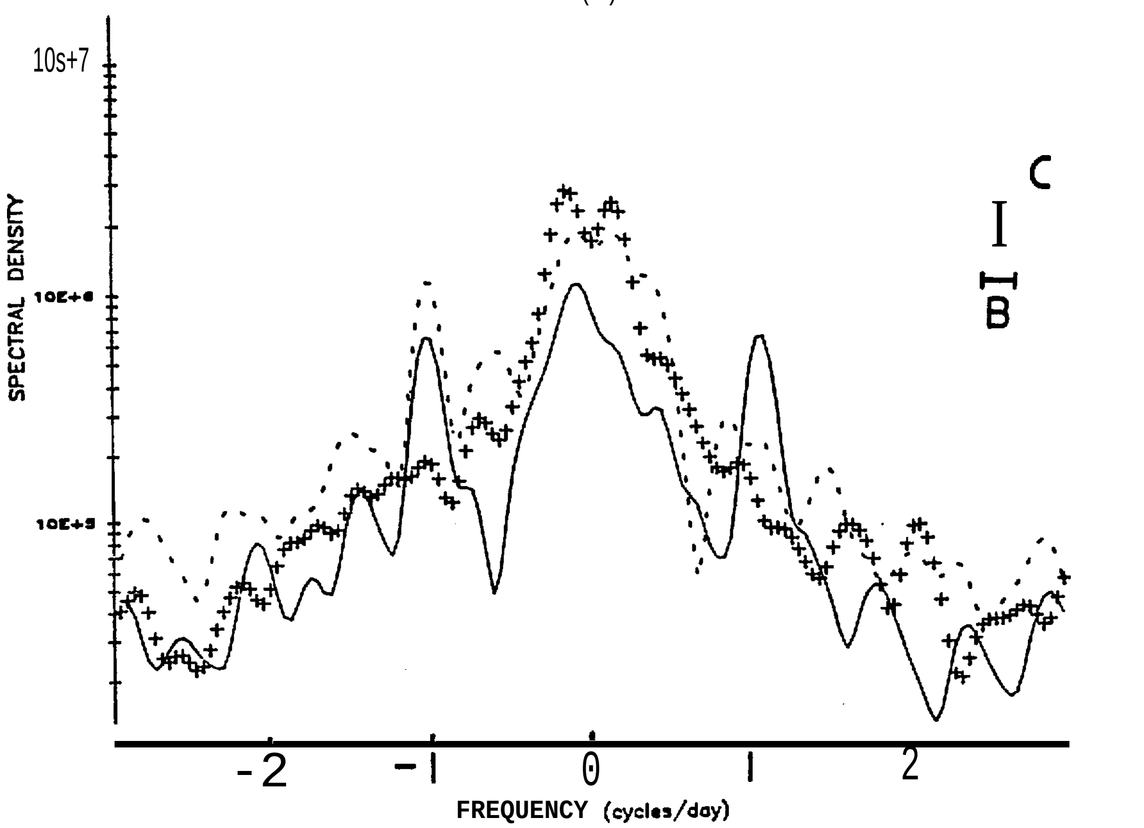


(b)

Fig. B4. Time series rotary spectra of surface wind velocity dsta from Unalakleet, Northeast Cape, and Nome for (a) May 1965 and (b) November .1965. The 95% confidence limits (C) and bandwidth (B) are ahown.



(a)



(b)

Fig. B5. Time series rotary spectra of surface wind velocity data from Unalakleet, Northeast Cape and Nome for (a) January 1966 and (b) July 1966. The 95% confidence limits (C) and bandwidth (B) are ahown.

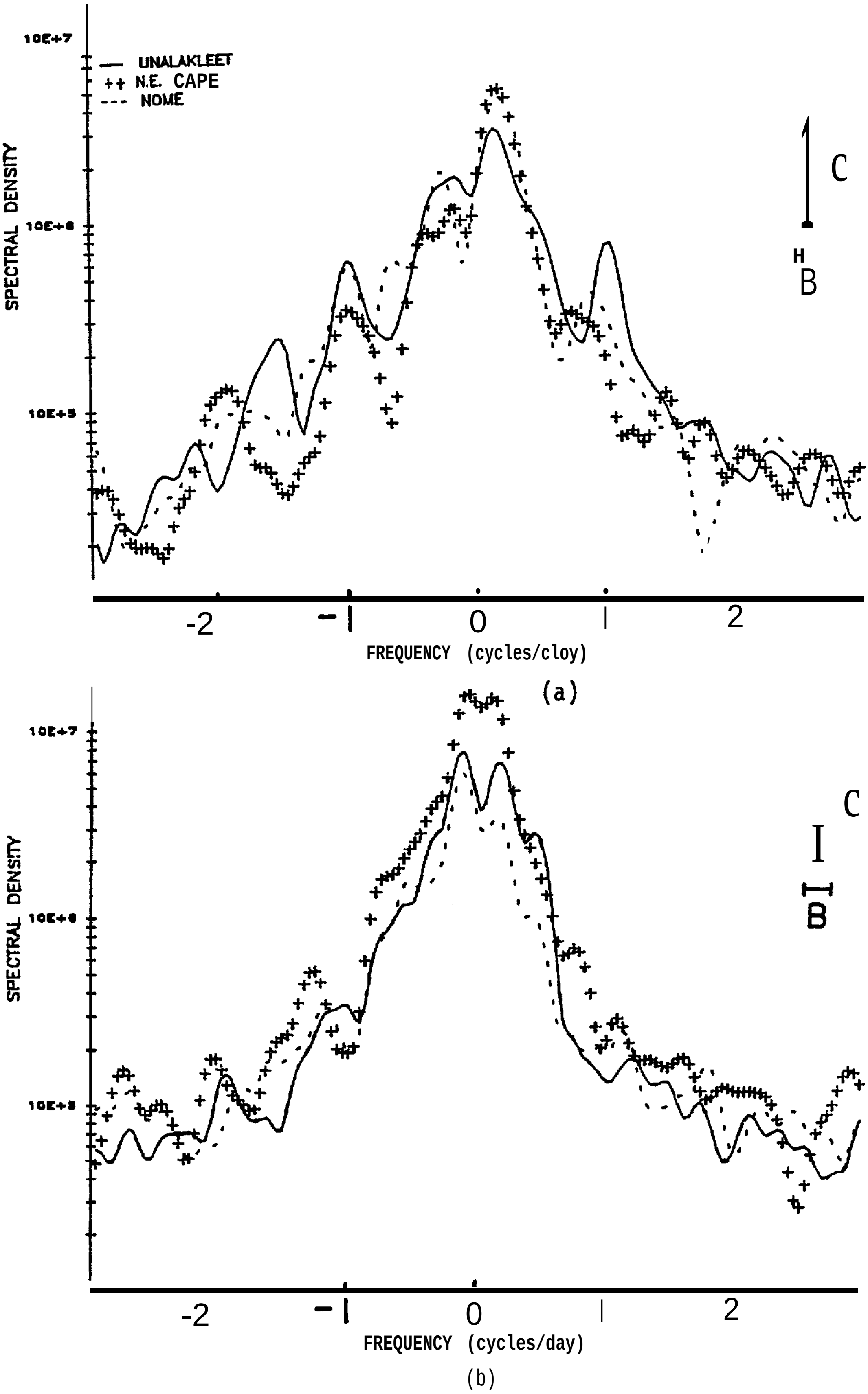
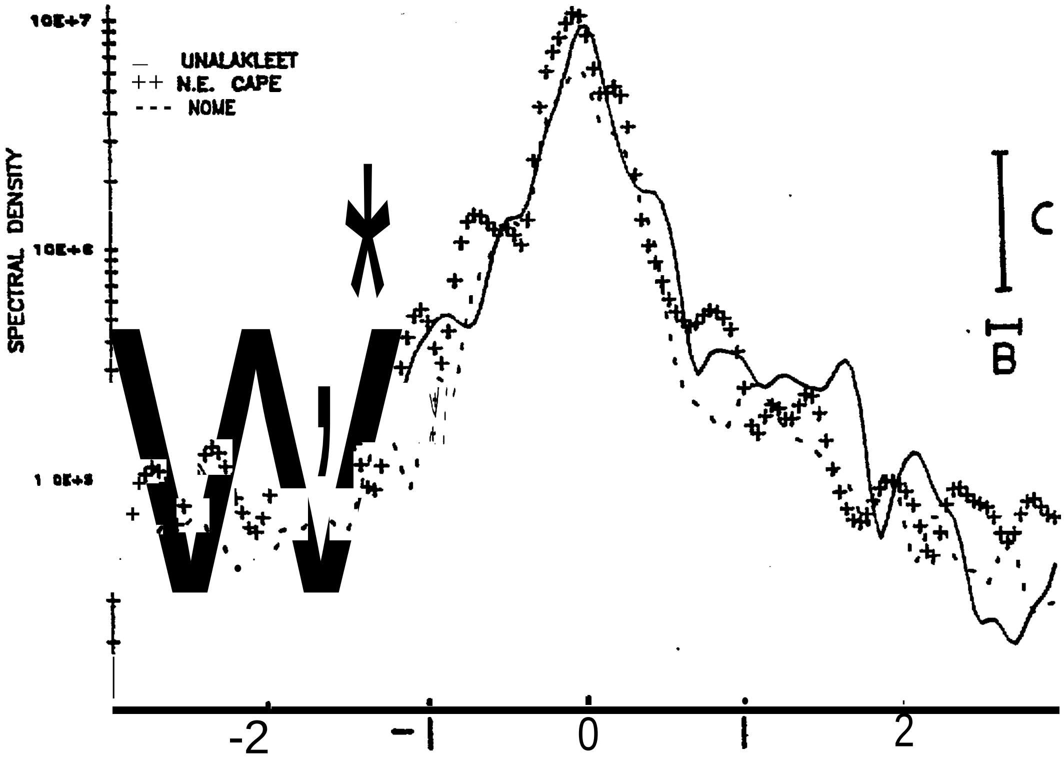
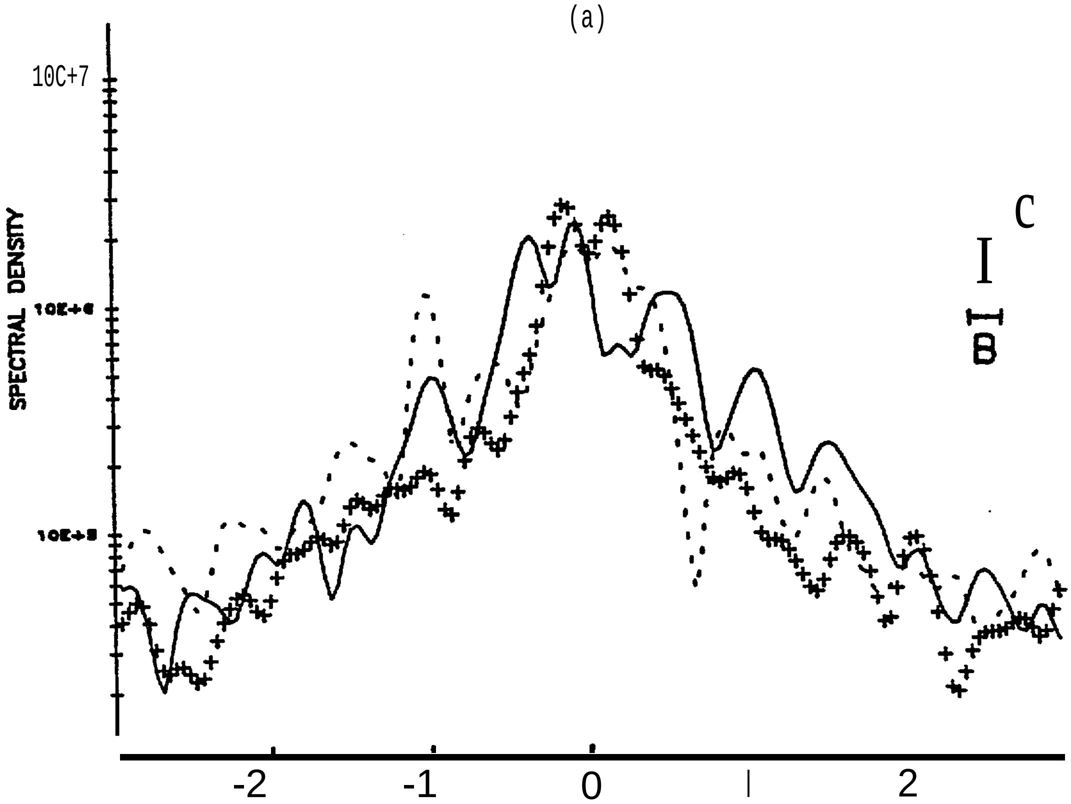


Fig. B6. Time series rotary spectra of surface wind velocity data from Unalakleet, Northeast Cape, snd Nome for (a) May 1966 and (b) November 1966. The 95% confidence limits (C) and bandwidth (B) are ahown.

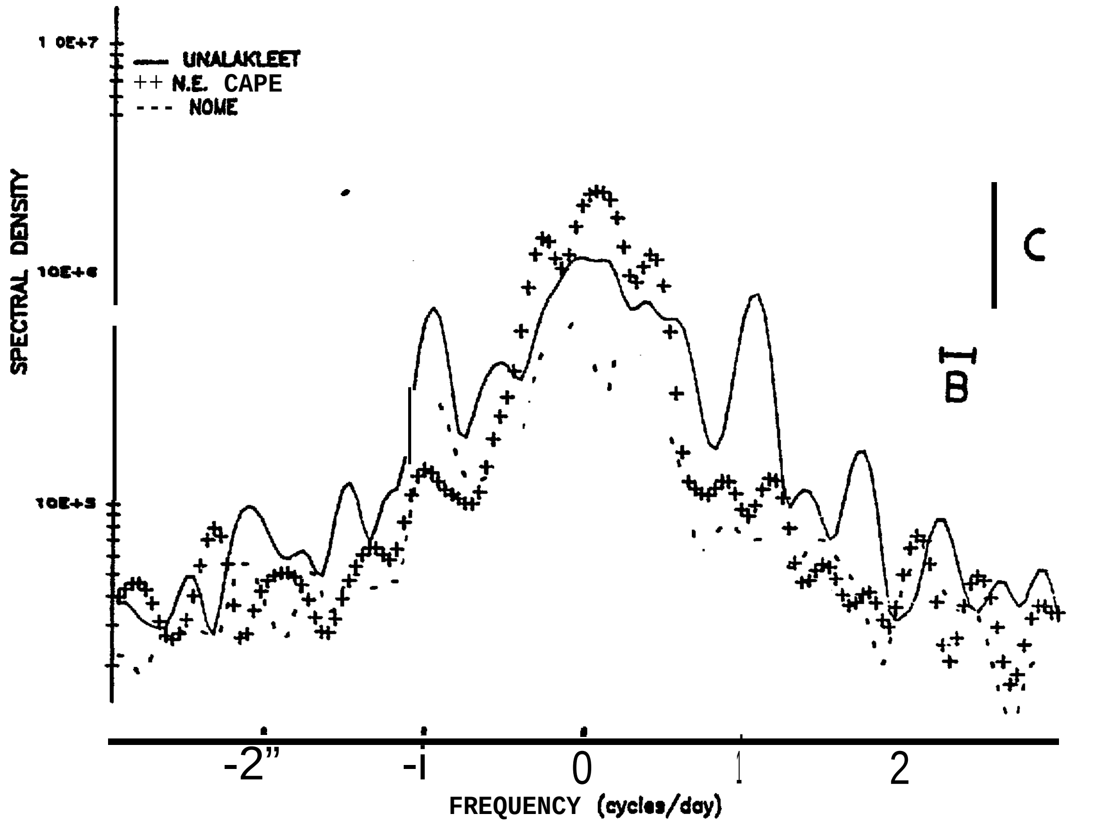


(a)

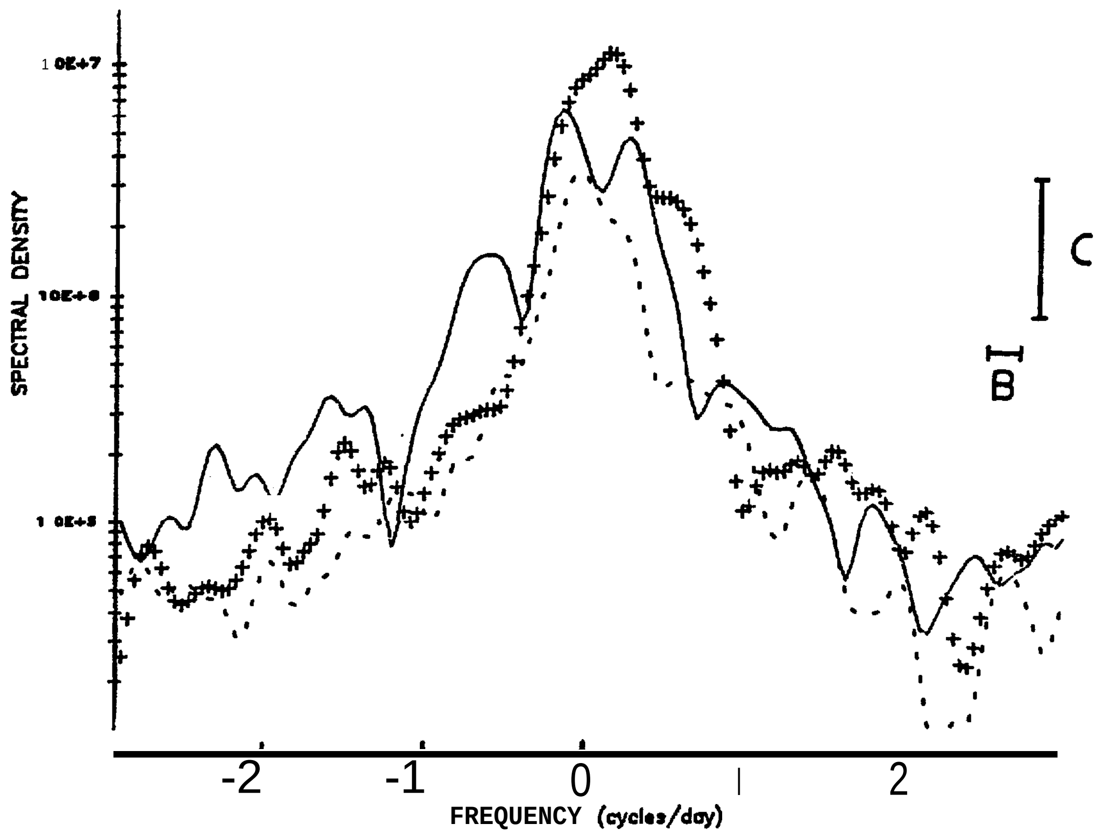


(b)

Fig. B7. **Time series rotary spectra of surface wind velocity data from Unalakleet, Northeast Cape and Nome for (a) January 1967 and (b) July 1967. The 95% confidence limits (C) and bandwidth (B) are shown.**

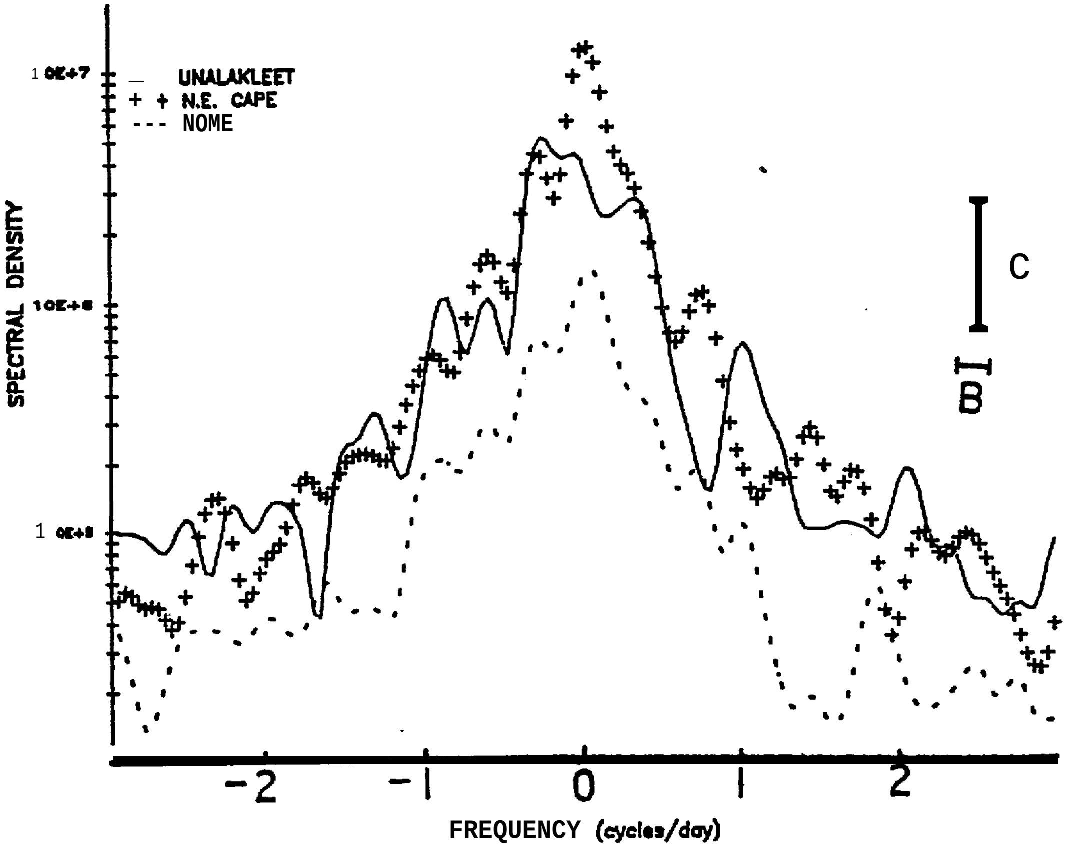


(a)

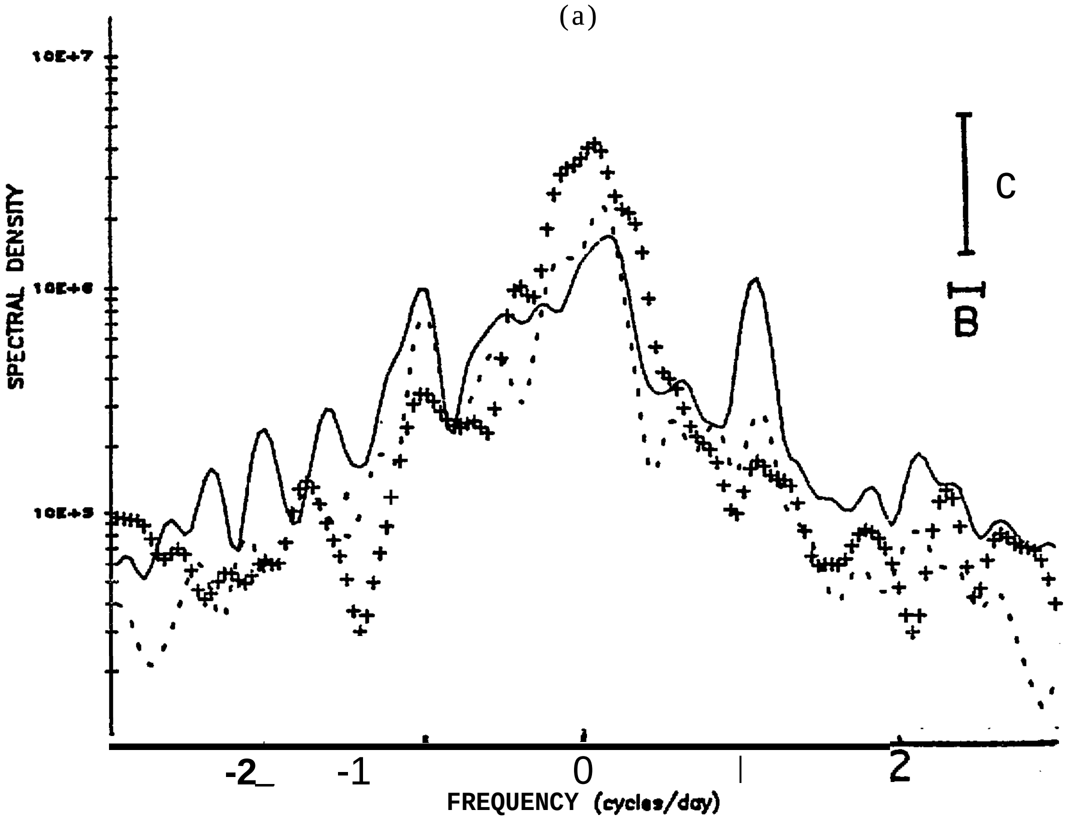


(b)

Fig. B8. Time series rotary spectra of surface wind velocity data from Unalakleet, Northeast Cape, and Nome for (a) May 1967 and (b) November 1967. The 95% confidence limits (C) and bandwidth (B) are shown.

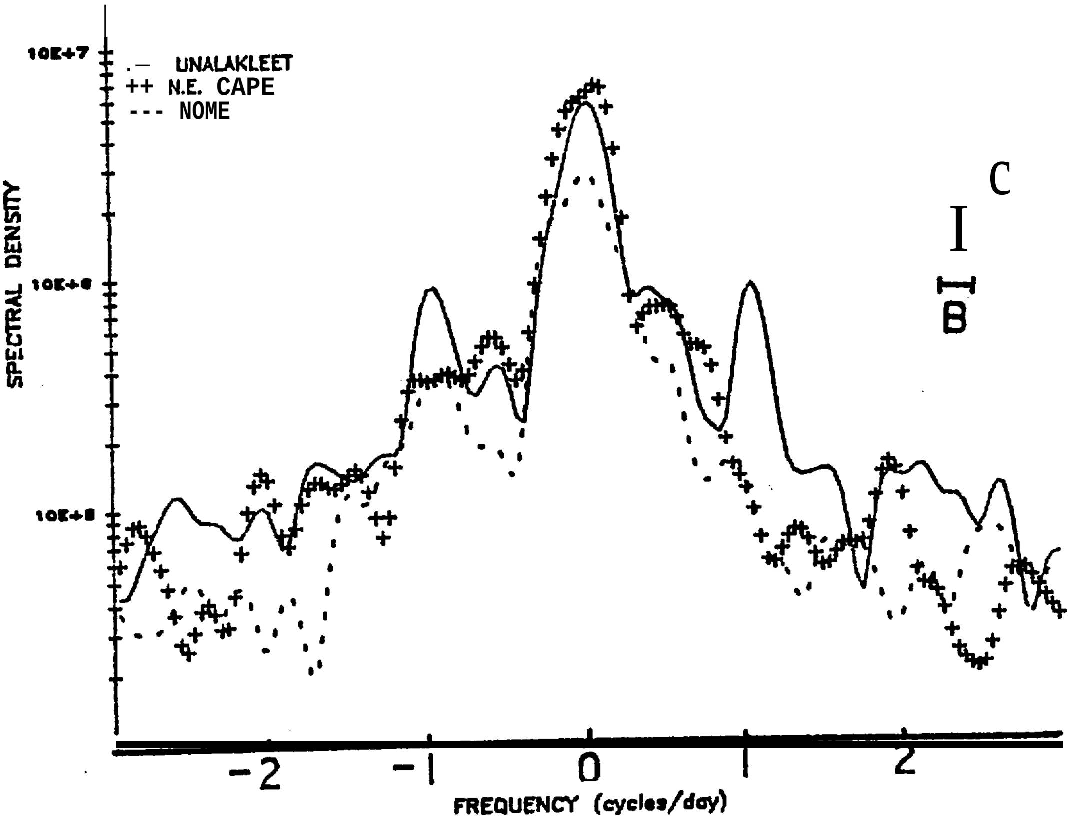


(a)

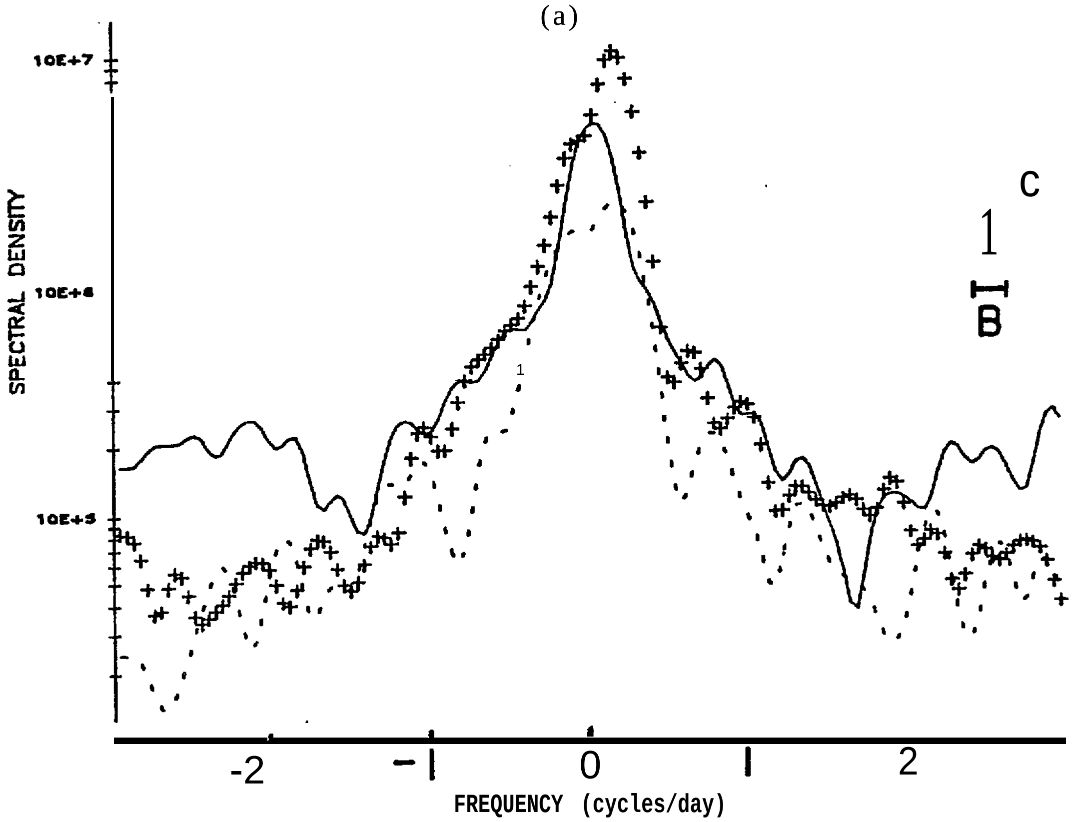


(b)

Fig. B9. Time series rotary spectra of surface wind velocity data from Unalakleet, Northeast Cape and Nome for (a) January 1968 and (b) July 1968. The 95% confidence limits (C) and bandwidth (B) are shown.



(a)



(b)

Fig. B10. Time series rotary spectra of surface wind velocity data from Unalakleet, Northeast Cape, and Nome for (a) Play 1968 and (b) November 1968. The 95% confidence limits (C) and bandwidth (B) are shown.